Pablo de Olavide University

Management and Marketing Department

DOCTORAL DISSERTATION

ENABLING INNOVATION AT THE LEVEL OF FIRMS, ALLIANCES AND CLUSTERS: A STUDY OF SPANISH BIOTECH INDUSTRY

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DEDICATION

I dedicate this dissertation to my family.

Захваљујем се мојој мами, тати и брату на безусловној подршци, беспрекорном поверењу и вери у мене. У истој мери сам захвална целој мојој породици. Посебно морам да издвојим моју тетку Весну и Стојанку које су ме бодриле и улагале у мене током целог мог школовања; моју Јеку чији пример о маштању сам следила и надам се да никад нећемо изгубити наше снове; моју баку Невенку која је увек уз мене и која ме је научила да будем вечити борац.

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Thank you all!!!

This is our journey…

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CHAPTER I

INTRODUCTION

Innovation in knowledge-intensive industries is increasingly becoming an interactive process that involves formal and informal relationships between different agents as well as the exchange of tacit and explicit knowledge. It is driven by research and the relations between scientific, technological and market knowledge. Knowledge and resources required for the development of innovations are distributed everywhere in the environment. Therefore firms have to rely on external collaborations to exchange knowledge for innovation purposes. Definitely the locus of innovation cannot be considered anymore at the level of the firm in isolation. Knowledge exchanges at different levels suggest the necessity to study how innovation can be improved by certain enablers not only at the level of the firms but also in the alliances and in the cluster that firms belong to.

Alliances enable organizations to exchange valuable knowledge, resources and share costs and risks (Hagedoorn, 1993; Gulati, 1998; Dooley and O'Sullivan, 2007). The complex and multidisciplinary nature of the knowledge base in certain sectors is considered one of the main reasons that lead companies to establish alliances (Hagedoorn, 1993; Ozman, 2009). Alliances allow firms to access the capabilities for competitive advantage because often the knowledge necessary for innovation is tacit and hardly transferable across organizational boundaries using other means (Koka and Prescott, 2002). The network of alliances represents a conduit that channels the flow of information and know-how between organizations in the network (Ahuja, 2000; Owen-Smith and Powell, 2004).

Collaborative networking by means of alliances is often used to justify and explain the attractiveness and persistence of clusters (Hendry and Brown, 2006). There is a significant body of evidence and economic analysis which demonstrates the importance of clusters to economic growth principally because of their ability to improve innovation and productivity in a number of ways. According to Porter (1990) firms benefit from sharing knowledge about best practices and reduce costs by jointly sourcing services and suppliers. The same author claims that the efficiency of a cluster is higher compared to that of each company separately due to fact that each company generates externalities for others and that improve their abilities to innovate. Spatial proximity offered by cluster seems to enhance the processes of knowledge creation activity and innovation. Knowledge transfer is facilitated through frequent interactions which in turn, also, encourage the formation and efficiency of collaboration between corresponding organizations.

Clusters have the innovation as one of their main objectives, by combining three basic pillars of society such as business, government and research institutions. Interorganizational networking of all these agents located in a cluster promotes the development of knowledge flows and human capital and allows them to develop their own competencies which in turn, foster innovations. The clusters experts have highlighted the great potentiality these agglomerations have for small and medium businesses (Porter, 2000, Cooke 2004) which nowadays are facing the increasing globalization of markets. The influence that clusters and interorganizational networks have on innovative activity of firms has generated a strong line of work that continues to yield interesting proposals on the phenomenon of business innovation.

From the perspective of knowledge management approach it can be said that clusters, alliances and firms represent different levels in each of which a great deal of knowledge is generated and exchanged. In our research we propose that certain factors in each of these levels may improve the effectiveness of such knowledge exchanges, which in turn, will improve the innovation performance of firms.

Thus, our research question is:

Which enablers should be present at the level of firm, alliances and cluster in order to improve the innovation performance of companies?

In order to answer this research question we will have to unpack it into several sub-questions. These sub-questions are addressed in the following chapters of this thesis in the way:

i) How the diversity of partners in a certain alliance for innovation affects innovation performance, and how this influence can be moderated by certain features of the own alliance.
ii) Whether and how firms' alliance portfolio configuration determines scientific and technological performance and contributes to the growth of small and medium sized firms.

iii) What is the role of firm's scientific capabilities for technological innovation, in interaction with science/industry relationships?

iv) How industrial, scientific and supporting driving forces enable technological development within cluster?

We will focus our research on the biotechnology industry which is extensively clustered and where companies are embedded in a dense network of interorganizational relationships. Biotechnology is rapidly developing industry and there are large gains from innovations. In the rapidly-developing field of biotechnology, the knowledge base is both complex and expanding and the sources of expertise are widely dispersed. Thus, biotechnology firms need partnerships of all kinds – with knowledge generating institutes, large pharmaceutical firms and other companies. When uncertainty is high, the external collaboration is required to benefit from new opportunities and advances. This view is proved with the claim of Powell (1998) about mutual interactions within the institutions and organization in biotechnology field: "Progress with the technology goes hand-in-hand with the evolution of the industry and its supporting institutions. The science, the organizations, and the associated institutions practices are co-evolving." Hence, modern science-based industries such as biotechnology are essentially determined through networking and collaboration because of the complexity of knowledge and technologies they need to include (Hendry and Brown, 2006).

The features of this industry as well as the nature of biotechnology activity which may have a significant influence on improving the quality of people life, make biotech firms an interesting object of study, in order to analyse how certain factors of various kinds can contribute to the success of these companies and the development of the sector. We contribute to the research on innovation management by bringing together enablers of innovation located in three different but very interrelated levels, which are firms, alliances and clusters. The presence of such enablers can enhance the effectiveness of knowledge exchanges that take place in each level and improve the innovation performance of biotechnology firms.

The population for our study is composed of dedicated biotech firms located in five relevant Spanish clusters. They are BioBasque, BioRegion of Catalonia, Bioval, Madrid Biocluster and Andalusia BioRegion. These clusters represent the 80% of total internal expenditures in R&D and 77% of the total employment in biotech activities in Spain.

As mentioned previously every chapter of this thesis addresses one specific question which will help us to find answer on our overall research question and determine enablers of innovation at firm, alliance and cluster level. In our research we consider that at each level the exchanging and creation of knowledge takes place. In the following we set the purposes of each study.

The second chapter deals with characteristics of firms' most important alliance for innovation and factors that may influence the innovation performance. Based on previous literature about the effects of alliance partner diversity on performance (Duysters and Lokshin, 2011; de Leeuw et al, 2014; Jiang et al., 2010; Wuyts and Dutta, 2014) we propose that there is an inverted U-shaped relationship between alliance partner diversity and innovation performance. Moreover, as it has been claimed that contingent effects should be considered (Schilling and Phelps, 2007; Wassmer, 2010; Zheng and Yang, 2015), we also propose that two attributes, relational social capital as well as the codifiability of the knowledge shared in the alliance, strengthen the effect of alliance partner diversity on innovation performance.

The third chapter examines firm's alliance portfolio and captures possible differences of its configuration regarding to quantity as well as quality. Wassmer (2010) emphasized that there is a scarcity of empirical evidences on overall characteristics of alliance portfolio configuration which has prevented researchers from understanding its impact on innovation performance of firms. Thus, our study attempts to provide a comprehensive approach of relationship between alliance portfolio configuration and performance. In line with various streams of the literature (Baum et al., 2000; George et al., 2002; Zaheer and George, 2004; Al-Laham et al., 2010; McCann and Folta, 2011; Love et. al, 2014; Ozer and Zhang, 2015) we propose that most of the inter-firm variation in alliance portfolios has to do with differences in alliance portfolio size, in the types of alliances and their local versus international dimensions. We take a closer look in alliance types, specifically their exploratory versus exploitative nature, their geographic proximity and international orientation of alliance partners which may have particular influence on innovation of small and medium sized biotech firms. Moreover we make distinction of three types of performance (scientific, technological and economic) and test the particular relationships among them, representing the full perspective of the impact that firm's alliance portfolio configuration has on each one.

The fourth chapter was inspired from the empirical results of previous study as interesting findings were found indicating tight relationships between science and technology. Previous literature (Cassiman and Veugelers, 2006; Laursen et al., 2011) has called for further contributions on examining potential benefits of combining internal and external research activities for innovation. Thus, we studied how capabilities of the firm to develop science internally as well as to ally externally with scientific partners may influence its technological development. In this sense, we suggest that firm which has greater scientific capabilities is more prone to develop technological innovation. We also propose that this effect may be moderated by the local science-industry relationships such as: when firms form R&D alliances with local research institutes and when academics create spin-offs.

The fifth chapter analyses some features of the Spanish biotech clusters regarding their composition, structure, and nature and contribution of their policies which may explain differences in their performance. While the cluster provides access to a large stock of knowledge, this does not necessarily imply that knowledge sharing will take place, so we need to give attention to the impact that certain variables at the cluster level have on formation of effective partnerships between different actors. In fact, collaboration between industry, research institutes and government is a necessary precondition for the long-term growth of the cluster and has to be increased to ensure the creation of innovation. Therefore, it is imperative that within the cluster certain factors are present to facilitate the exchange of knowledge and the development of innovation activities. We propose and analyse three factors as enablers of knowledge exchange and innovation: supporting, scientific and industrial driving forces. By conducting qualitative research we explain differences in these driving forces within Spanish biotech clusters. Our in depth case study analysis will allow us to conclude if and how cluster can enable the innovation.

Finally, the sixth chapter concludes the thesis pointing out its main contributions, implications for managers and policy makers that result from our study. The limitations and future lines of research are also addressed in this last chapter.

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CHAPTER II

COPING WITH DIVERSITY IN ALLIANCES FOR INNOVATION: THE ROLE OF RELATIONAL SOCIAL CAPITAL AND KNOWLEDGE CODIFIABILITY[2]

1. INTRODUCTION

Alliances are increasingly considered a key element for innovation, given that they enable organizations to exchange valuable knowledge resources and share costs and risks (Dooley, 2007; Gulati, 1998; Hagedoorn, 1993). They can be defined as any cooperative agreement voluntary initiated between firms that can involve "exchange, sharing or co-development, and it can include contributions by partners of capital, technology, or firm-specific assets" (Gulati and Singh, 1998, p. 781). This phenomenon becomes particularly important in knowledge-intensive industries usually consisting of a set of many different technologies for which unique and differentiated capabilities are required. This is the case for the biotech industry on which this research is focused. Given the breadth and pace of technological change in this industry, exploring all facets of the R&D without specialized external support is not possible even for large pharmaceutical companies (Pisano, 2006). In turn, biotech companies that support these R&D activities of big pharma firms have to look outside themselves to find the competences to commercialize their innovations, given that they are not likely to be successful in carrying out the entire set of business functions along the value chain (Oliver and Liebeskind, 1997; Powell, 1998). Therefore, the biotech industry is characterized by the existence of multiple inter-organizational agreements among different types of partners trying "to build knowledge at an inter-organizational level" (Nonaka, 1994), in order to achieve their innovation aims.

Thus, alliances do matter for innovation performance in the biotech industry. For the purposes of this paper, we consider alliances as formal agreements established between two or more organizations, with specific objectives related to the R & D and innovation (Powell et al., 1996). However, the performance achieved by alliances for innovation does not always meet the companies' expectations, so trying to explain how certain characteristics of these alliances contribute to their success remains as yet a relevant research question (Sampson, 2007; Schilke and Goerzen, 2010; Wassmer, 2010).

[2] This chapter is transformed to the article which has been conditionally accepted in British Journal of Management

Our research focuses on alliance partner diversity, referred to a certain alliance of the firm. It represents an alliance attribute that may have a particularly relevant effect on performance (Goerzen and Beamish, 2005; Nieto and Santamaria, 2007). Although this construct has been mainly addressed in the literature about alliance portfolio (Duysters et al., 2012; Faems et al. 2010; Goerzen and Beamish, 2005; de Leeuw, Lokshin and Duysters, 2014), their discussion about the benefits and drawbacks of having very diverse partners is also useful for supporting our theoretical discussion about the impact of partner diversity on performance in a certain alliance.

Diverse partners can provide access to nonredundant knowledge and, therefore, give more opportunities for valuable learning (Teece, 1998; Wuyts and Dutta, 2014). Indeed, a single type of partner hardly could provide all the specialized knowledge and resources that are necessary in industries characterized by a high pace of technological and scientific change. Thus, in these industries, firms increasingly try to configure a set of diverse partners in their alliances, including customers, suppliers, research institutions and so on (de Leeuw et al., 2014). Owen-Smith and Powell (2004) have highlighted the innovation benefits for science-based firms, coming from their alliances with diverse types of organizations (universities, small firms, public research institutes and large pharmaceutical companies). Hence, alliance partner diversity has become a key feature of alliances in biotech industry (Hendry and Brown, 2006).

In spite of their undeniable advantages, research has not been conclusive about the effects of alliance partner diversity. Indeed, potential benefits of diversity could be undermined by some problems associated with sharing and transferring very diverse knowledge. In this sense, some studies report a negative relationship between alliance diversity and performance, reflecting the drawbacks of having diverse partners (Faems et al., 2010; Goerzen and Beamish, 2005).

Given that arguments for and against alliance diversity may be equally compelling, more recent studies are addressing curvilinear relationships in order to reconcile these contrary arguments (Duysters and Lokshin, 2011; de Leeuw et al, 2014; Jiang et al., 2010; Wuyts and Dutta, 2014). That is, having diverse partners contributes to improve the performance but, beyond a certain level of diversity, its benefits could be difficult to reap given the hindrances to share and transfer knowledge among firms that have little in common (Kogut and Zander, 1992; Lane and Lubatkin, 1998).

Although this curvilinear approach can help to overcome the lack of consistency in the research, not all of the firms are likely to equally benefit from having diverse partners (Wuyts and Dutta, 2014). Thus, some contextual factors may affect this relationship. Indeed, the previous research is increasingly claiming that the impact of different dimensions of alliance configuration on performance cannot be precisely assessed without understanding the contingent effect involved (Schilling and Phelps, 2007; Wassmer, 2010; Zheng and Yang, 2015). In this sense, Sampson (2007) states that the effect of organizational form on performance depends on technological diversity between partners. Terjesen et al. (2011) examined how the interaction between manufacturing capabilities in the alliance and alliance partner diversity affects venture performance. At the level of alliance portfolio, Duysters et al. (2012) demonstrated that alliance experience and alliance capabilities moderate the diversity-performance relationship. Oerlemans et al. (2013) found that technology management tools moderate the effect of alliance partner diversity and firm's innovation outcomes. Wuyts and Dutta (2014) demonstrated that internal knowledge creation strategies improve the impact of portfolio diversity on product innovation.

The literature referred above suggests that the relationship between alliance partner diversity and innovative outcomes may be influenced through conscious and targeted managerial efforts (Oerlemans et al, 2013); that is to say, contextual factors addressed in previous research include capabilities, tools, alliance forms, knowledge strategies and so on. Nevertheless, not only may these conscious efforts and actions moderate the effect of diversity, but also certain attributes of the alliance itself could influence how diversity has an impact on innovation performance. In this sense, given that knowledge is not likely to spontaneously flow among diverse partners, alliance attributes that make easy knowledge transfer are particularly relevant in this context. In our research, we propose that relational social capital as well as the codifiability of the knowledge shared in the alliance represent effective enablers of this process by easing and smoothening knowledge transfer among a diverse set of partners.

Regarding relational social capital, it is increasingly becoming a prominent concept for describing and characterizing the set of relationships of a certain firm (Inkpen and Tsang, 2005). Research on social capital has traditionally highlighted its relational and structural dimensions (Moran, 2005). The structural dimension focuses on the pattern of relationships between actors, while the relational dimension refers to the quality of such relationships, regarding attributes such as trust and closeness (Nahapiet and Ghoshal, 1998; Moran, 2005). Our research is focused on the relational dimension of social capital, which is considered a critical variable that may affect interfirm knowledge transfer (Inkpen and Tsang, 2005) and, therefore, may influence how effective knowledge transfer among diverse partners can be.

The effectiveness of knowledge transfer between diverse alliances partners may not only depend on the quality of their relationships, but also on the type of knowledge they are transferring to each other (Zander and Kogut, 1995; Schilling and Phelps, 2007). Indeed, research has demonstrated that knowledge types may have different effects on organizational process (Nonaka, 1994). Among the different knowledge typologies analysed by the literature (tacit vs. codified, complex vs. simple, systematic vs. non-systematic, etc.), this paper focuses on the tacit-codifiability continuum. Codified knowledge is defined as the one that can be transmitted without any loss of its integrity, when the transmitter and receiver share the syntactic rules necessary for its decipherment (Kogut and Zander, 1992). Tacit knowledge is is implicitly acquired and cannot be fully articulated (Gopalakrishnan et al., 1999). It is related to know-how and based on experience (Nonaka, 1994). When alliances involve very diverse partners, the process of knowledge transfer becomes more complex, and the degree of codifiability may influence the extent to which all partners receive full information without any loss of content.

Therefore, the aim of this paper is twofold: first, we discuss the controversial effect of alliance partner diversity on innovation performance. Second, we explain that this effect may be moderated by two attributes: the quality of relationships among partners and the type of knowledge shared.

The empirical analysis of a sample of 90 biotech companies shows that there is indeed an inverted U-shaped relationship between alliance partner diversity and innovation performance while we confirm that the moderating effects of relational social capital and knowledge codifiability are helping reap the benefits of more diverse partners. These findings contribute to the current research on alliances for innovation by providing empirical evidence on why some alliances perform better than others. Also, our results suggest that the study of alliance partner diversity, as determinant of alliance performance, should not be addressed in isolation. By considering the moderating effect of certain characteristics of the alliance, such as relational social capital and knowledge, the influence of alliance partners' diversity on innovation performance can be better understood.

The paper proceeds as follows. The next section presents the theoretical background that led us to establish the hypotheses. The following sections test such relationships empirically. Finally, the main conclusions, contributions, managerial implications and limitations are presented.

2. THEORETICAL BACKGROUND AND HYPOTHESES

2.1. The effect of alliance partner diversity on innovation performance

Research on alliances stresses the relevance of interorganizational relationships for accessing different types of resources and creating competitive advantages. These are resources that may not otherwise be available to a firm or would require years to accumulate (Baum et al., 2000). From a resource-based view, Sarkar et al (2009) state that extrafirm resources accessed through alliances represent valuable, rare and noninimitable resources and will positively impact performance. In this sense, they propose that alliances must be understood as resource and knowledge repositories that can explain why firms differ in their profitability. This is what Lavie (2006) has named the resource-based competitive advantage gained by interconnected firms.

When the firm simultaneously collaborates with different types of partners, it is more likely to access a wide variety of resources (Wassmer, 2010). In the case of alliances for innovation, firms can access different knowledge and capabilities, which, in turn will improve the innovation performance (Faems et al, 2005). Thus, rather than the number of partners or alliances *per se*, it is the diversity of knowledge to which an organization has access via its partnerships that affects its innovation performance (Baum et al., 2000; Phelps et al., 2012; Zeng et al., 2010). Therefore, the composition of the alliance in terms of the diversity of partners is a key factor that may have a particularly relevant effect on performance (Goerzen and Beamish, 2005; Wassmer, 2010) and can help to understand why some alliances are more successful than others.

Alliance partner diversity refers to the degree of heterogeneity in the types of partners with which a firm allies (Rothaermel and Deeds, 2006; Terjesen et al., 2011). It includes universities and research labs, suppliers, buyers, competitors, consultants and so on, all of which possess different types of knowledge (Oerlemans et al., 2013).

The literature suggests opposing arguments about how alliance partner diversity affects alliance innovation performance. On the one hand, it is broadly argued that knowledge building requires dissimilar but complementary bodies of knowledge (Boschma, 2005), provided by a set of diverse partners. Indeed, as Dyer and Nobeoka (2000) state, the main reason why a network is superior to a firm is that there is greater diversity of knowledge in the former than in the latter. Alliance partner diversity exposes firms to more pieces of information from which to learn, enhancing the breadth of perspective, the cognitive resources and the problem-solving capacity of the firm (Goerzen and Beamish, 2005). This exposure to diverse ideas and experiences benefits the firms by making them think 'out of the box' and by stimulating learning (Vasudeva and Anand, 2011). Thus, as the level of diversity increases, the opportunities for valuable learning increase as well (Teece, 1998), because partners with diverse capabilities have more to learn from each other than from similar partners (Sampson, 2007). Some studies on biotech industry support this idea that different types of partners, which provide access to diverse information, knowledge and capabilities, are more likely to generate innovation (Al-Laham et al., 2010; Powell et al., 2005). Similarly, Baum et al. (2000) showed that startup biotech firms enhance their performance by configuring alliances into an efficient network that provides access to diverse information and capabilities.

On the other hand, the literature also states that while diversity may represent an opportunity to gain access to new and valuable knowledge, it could become a barrier for the effective inter-organizational learning. That is, the potential benefits of collaboration between highly diverse partners may be difficult to reap, because the costs of sharing and transferring knowledge may be very high (Kogut and Zander, 1992; Lane and Lubatkin, 1998). For instance, Faems et al. (2010) found that the total effect of technology alliance portfolio diversity negatively influence a firm's profit margin. Vasudeva and Anand (2011) state that as alliance partners' diversity increases, lower levels of synergies and shared experiences can be exploited and, thus, more learning resources may be needed. Studying open innovation

Laursen and Salter (2006) found that firms may over-search the external environment with a detrimental outcome as the result, because the more diverse contributions a firm receives, the more difficult it becomes to absorb this diverse knowledge and improve innovation performance. Similarly, Oerlemans et al. (2013) state that a high level of alliance partner diversity increases the costs of coordination, monitoring and communication, as well as the probability of opportunism. In fact, what organizational learning theory has largely suggested is that it is the similarities between partners, rather than their differences, that facilitate the absorption knowledge, which will in turn affect alliance performance positively (Hedlund, 1994; Parkhe, 1991). It seems that people learn new ideas by associating those ideas with what they already know, while firms will better identify and absorb external knowledge when it is close to their existing knowledge base (Boschma, 2005; Cohen and Levinthal 1990; Lane and Lubatkin, 1998). Therefore, from this point of view, in order to ensure the success of the alliances, the knowledge and technology shared and exchanged among partner firms should have a certain degree of similarity.

The arguments above lead to the fact that the relationship between alliance partner diversity and alliance innovation performance is an inverted-U-shape, as has been proposed also by Sampson (2007) and, with a similar logic, by Jiang et al. (2010), Duysters et al. (2012), Oerlemans et al. (2013) and de Leeuw et al. (2014) at the level of alliance portfolio. In sum, alliance partner diversity should be wide enough to represent an appropriate base for knowledge transfer and recombination but not so wide as to prevent efficient assimilation (Sampson, 2007). Therefore, what can facilitate the alliance success and development of innovation is a moderate level of diversity. Hence, our first hypothesis is formulated as follows:

Hypothesis 1: The relationship between alliance partner diversity and innovation performance takes the form of an inverted U-shape.

2.2. The moderating role of relational social capital

As argued, and in spite of its advantages, the wide diversity of knowledge provided by very distinct partners might make effective learning difficult and, as a consequence, it may harm innovation performance. In this section, we argue that the relational dimension of social capital, understood as the quality of the relationships among partners, could mitigate the disadvantages of alliance partner diversity and leverage its positive influence on innovation performance. The literature on knowledge and social capital claims that relationships characterized by friendship and trust (the relational side of social capital) provide information and learning benefits (Maurer and Ebers, 2006; Powell et al, 1996). Therefore, organizations involved in alliances characterized by a strong relational social capital are more likely to obtain the benefits of having very diverse partners (Phelps et al, 2012).

Indeed, Ahuja (2000) states that the benefits of collaboration, that arise from combining skills, sharing knowledge and conducting joint projects, presume the existence of significant trust between partners. In absence of trust and shared norms of behaviour, sharing knowledge and combining skills are likely to be difficult (Coleman, 1988).

The nature and benefits of this type of relationships based on trust have been addressed in previous research under the framework of social capital, regarding its relational dimension. Social capital has been defined as the actual and potential resources embedded within, available through and derived from the networks of relationships by an individual or social unit (Nahapiet and Ghoshal, 1998, p. 243). The relational side of social capital on which our research is grounded refers to different types of relationships, be it friendship, trust or respect (Nahapiet and Ghoshal, 1998).

Relational social capital among partners can contribute to leverage the positive effect of diversity on innovation performance for two main reasons. First, relational social capital can help mitigate the difficulties in transferring and integrating very diverse knowledge. Overall, the literature has addressed the fact that quality relationships enhance comprehension of the transferred knowledge because trust allows for greater openness and cooperation (Pérez-Nordvedt et al., 2008). In this sense, Tiwana (2008) demonstrated that ties characterized by trust, reciprocity and proximity, help integrate diverse knowledge, skills and capabilities. Individuals connected by this type of ties serve as brokers, translators and interpreters of a broad repertory of specialized knowledge from alliance partners that, in turn, influence the innovation performance positively. Other authors state that when relational social capital exists among partners (i.e., trust, reciprocity and social identity), they are more disposed to share and receive knowledge, and are more likely to expend effort to ensure that partners understand knowledge exchanged sufficiently and can put into use the new knowledge acquired (Levin and Cross, 2004; Phelps et al., 2012).

The second reason has to do with the fear of opportunistic behaviour by the partners in the alliance, which represents an obstacle to share knowledge. As Gulati (1998) states, the problem of appropriation concerns in alliances is worsened by a heightened threat of opportunistic behaviour. If trust is not present in the relationship, the focal firm is likely to believe that its partner in the alliance may want to harm them. Thus, the former would be cautious in admitting some lack of knowledge and reluctant to learn from any transferred knowledge owing to fear that it might be wrong or misleading (Levin and Cross, 2004). When allied partners are very diverse and, therefore, the knowledge shared is as well, the information asymmetry makes this fear even a more important concern for firms. In this context, trust and reciprocity provided by relational social capital can help mitigate this fear. This creates a normative context in which decision-makers do not feel that they have to protect themselves from the opportunistic behaviour of others (Cuevas et al, 2013; Gulati and Singh, 1998; Inkpen and Tsang, 2005; Padula, 2008). By reducing concerns about loss of proprietary skills and knowledge, relational social capital encourages firms to be more willing to share knowledge and learn from their partners, even when they are very diverse and information asymmetry exists.

Summarizing, closeness and trust in the relationships among partners (the relational side of social capital), will help avoid some drawbacks when there is alliance partner diversity, by facilitating the comprehension of shared knowledge as well as by reducing the fear of opportunistic behaviour. As Phelps et al. (2012) state, given that relational social capital among alliance partners will enhance the transfer of knowledge, the organization involved in such alliance will improve its ability to benefit from diverse partners to increase innovation performance. Thus, we propose that:

Hypothesis 2: The inverted U-shaped relationship between alliance partner diversity and innovation performance is positively moderated by relational social capital among partners.

2.3. The moderating role of knowledge codifiability

As we have mentioned, alliances are complex organizational forms involving the transfer of resources between organizations with diverse knowledge and capabilities. Obviously, alliances with very diverse partners will involve high levels of complexity, and organizations must put their abilities into practice in order to achieve effectiveness in their knowledge exchange and to enhance the innovation performance. The knowledge-based view of the firm (Grant, 1996; Kogut and Zander, 1992, among others) argues that developing innovations by setting up alliances requires effective mechanisms to facilitate inter-organizational transfer of knowledge (Inkpen, 1996; Zander and Kogut, 1995). This section is devoted to explain how knowledge codifiability in the alliance process could reduce the complexity of these organizational forms and enhance the effect of diversity on innovation performance.

Knowledge could be defined in a wide sense as what is known (Grant, 1996) or, using Nonaka and Takeuchi's (1995) proposal, as the validated understanding and beliefs in a firm about the relationship between the firm and its environment. Among the existing knowledge-based issues, the distinction between tacit and explicit knowledge is important to understand organizational knowledge (Nonaka and Takeuchi, 1995). This is a familiar category (Gopalakrishnan et al., 1999; Grant, 1996; Nonaka, 1994; Polanyi, 1966) and generally describes the extent to which knowledge is or is not codifiable (Galunic and Rodan, 1998). Polanyi (1966) classifies human knowledge into two categories. On the one hand, he distinguishes explicit or codified knowledge, which is the knowledge that can be transferred through a formal language; that is, the knowledge that can be transmitted without the loss of its integrity if the transmitter and receiver share the syntactic rules necessary for its decipherment (Kogut and Zander, 1992). On the other hand, Polanyi defines tacit knowledge as having a personal quality that makes its formalization and communication difficult (Nonaka, 1994). Therefore, as knowledge tacitness increases, knowledge transfer becomes more complex (Windsperger and Gorovaia, 2011) to such an extent that it may become a barrier for knowledge transfer (Szulanski, 1996).

Knowledge transfer among companies provides opportunities for mutual learning and inter-organizational cooperation, which stimulate the creation of new knowledge and, at the same time, contribute to the organizational ability to innovate (Nielsen, 2005). This knowledge can be captured and codified in manuals, processes and software (explicit knowledge). While authors as Von Krogh et al. (2000) proposed that tacit knowledge is generally the source of a firm's innovation, when talking about alliances, especially with diverse partners, it is explicit knowledge the one that can be efficiently transferred and, therefore, will better contribute to the innovation performance (Windsperger and Gorovaia, 2011).

Even more, authors as Subramaniam and Venkatraman (2001) explained that tacit knowledge could be a key differentiator and potentially an important resource, however, they also explain that in order to develop new products between different actors, such knowledge should be codified. That is, while tacit knowledge comes from individual experiences and perceptions (Polanyi, 1966), for organizations to harness this knowledge and turn it into innovative capabilities, these experiences and perceptions must be processed into a collective understanding. Thus, they have to be transformed into explicit knowledge.

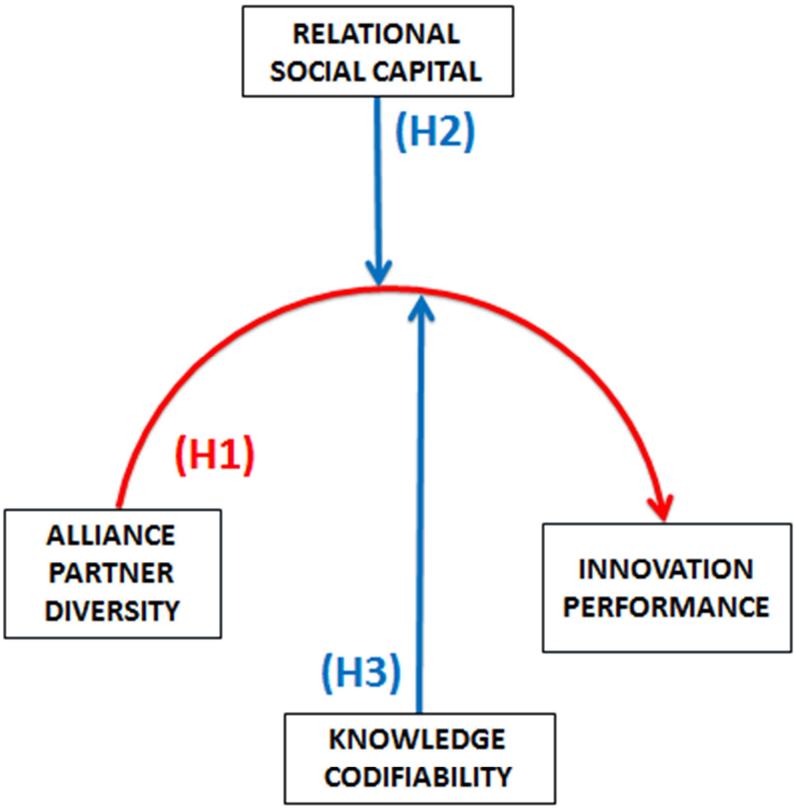
As we have previously mentioned, diverse alliances involve the transfer of knowledge between many different participants. A successful use of such knowledge requires that all partners receive the same information without any loss of meaning. Therefore, the initial tacit knowledge created in the individual minds should be codified in order to be transferred. In turn, as knowledge codifiability increases, the complexity associated with knowledge transfer between diverse partners is reduced. Then, by simplifying knowledge transfer, companies could obtain the maximum benefit of alliances with diverse partners. In this sense, when companies get to codify the knowledge involved in their innovations, the easier is that the people involved in the alliance can learn from such knowledge and the more successful the alliance will be.

Based on the previous ideas, we propose that the more codifiable the knowledge involved in the alliance, the easier it will be to transmit knowledge among diverse alliance partners. Therefore, we propose that knowledge codifiability enhances the relationship between alliance partner diversity and innovation performance. Thus,

Hypothesis 3: The inverted U-shaped relationship between alliance partner diversity and innovation performance is positively moderated by knowledge codifiability.

The following Figure 1 illustrates the model and hypotheses we have settled in this study.

Figure 1: Hypothetical model



3. DATA AND METHODOLOGY

3.1. Research Design and Sample

The nature of biotechnology activities, result of cross-industrial and cross-disciplinary scientific synergies, has led biotechnology companies to an extensive reliance on external collaborations that tend to take place in regional clusters. By clustering, biotechnology firms seem to benefit from being connected to a broad set of actors with expertise from different positions in the value chain (Chiaroni and Chiesa, 2006; Oliver and Liebeskind, 1997).

The population for this study is composed of biotechnology firms belonging to the main five clusters in Spain: Bioregion (Andalusia), Biobasque (The Basque Country), Biocat (Catalonia), Bioval (Valencia) and Madrid Biocluster. We built the database of companies of these clusters by matching the database of ASEBIO (Spanish Association of Biotechnology Companies) and the information found on the websites of the cluster agencies.

For our research, only companies that have biotechnology as its main activity have been considered, leading to a population of 285 firms. Data were collected through a personal survey during the last quarter of 2012 and first quarter of 2013. Our dataset is cross-sectional as we have only one observation per firm in this time period. Questionnaires were addressed to the CEO and/or the person responsible for R&D activities, and questions were referred to the most important alliance for innovation that the firm had established in the last five years. After eliminating those cases with missing data, ninety valid responses were obtained, which provided a usable response rate of 31.6%. In order to check for non-response bias, we compared mean differences between respondents and non-respondents for industry membership, number of employees, and revenue. No significant differences were found, suggesting that non-response bias was not present.

3.2. Measures

The measures were selected for this research after a wide literature review on innovation, alliances, relational social capital, knowledge and biotechnology firms. Relational social capital, knowledge codifiability and innovation performance are developed as multidimensional concepts measured using a seven-point scale ranging from 1=strongly disagree to 7=strongly agree. The items were drawn from existing studies and in the case of relational social capital and knowledge codifiability, adapted especially with respect to the network situation (See Appendix 1). Preliminary versions of the questionnaire were pretested in a small sample of companies in order to reduce ambiguities or difficulties in responding to the scale items and to ensure clarity. The measures and items are discussed below.

3.2.1. Dependent variable

Innovation performance of alliance. It was measured using Rese and Baier (2011) scale that assesses the ***new product performance with respect to the products developed in the networks***. As Rese and Baier suggest, this subjective assessment of performance can be sufficiently reliable if alliances have been rather recently formed and other precise performance indicators are not available. Managers assessed the outcome of the alliance with the following nine items: IP1: Because of the innovations new markets could be opened. IP2: Because of the innovations other new products became possible. IP3: The innovations were technically successful. IP4: Sales objectives could be met. IP5: Sales figure objectives could be met. IP6: The schedule was met. IP7: The budget was met. IP8: Time was used efficiently. IP9: Quality specifications were met. An exploratory factor Analysis (EFA) supports the convergent and discriminant validity of this measure. In order to obtain a unidimensional measure of innovation performance, Items IP4 and IP5 were deleted as they loaded in a different factor. Cronbach' alpha is 0.81 proving the high reliability of this scale. As it can be seen in Appendix 1 Innovation Performance of the alliance was loaded onto a separate factor with eigenvalues greater than 1 (3.36) accounting for 47.95 percent of the total variance.

3.2.2. Independent Variables

Alliance partner diversity. We measure this variable in two steps. First, it would range from 1 to 6, depending on how many different categories of partners participate in the alliance (similar to Duysters and Lokshin, 2011; Oerlemans et al., 2013). These categories are: a) universities, research institutes and centers; b) customers; c) providers; d) competitors; e) others and f) pharmaceutical firms. Second, we asked about the number of partners in each of these categories. Given that the number of partners in each category also slightly increases the diversity of partners in the alliance (i.e. three universities as partners implies more diversity than having only one), we corrected the first measure by adding a concentration index (HHI) that captures this internal diversity (Duysters et al., 2012). Finally, the variable alliance partner diversity was calculated by dividing this corrected measure by the maximum number of partner categories. The result of this calculation is a diversity score with a value between 0 (least diversity) and 1 (highest diversity), similarly to Blau's index of heterogeneity (Blau, 1977) which has been used in other studies from alliance literature (Powell et al, 1996; Oerlemans et al., 2013; de Leeuw et al., 2014)[3]. Even if the focus of our study is on the most important alliance, there is enough variation in the distribution of the number of partners per samples' firm.

Relational social capital was measured using our own items developed from previous literature scales (Inkpen and Tsang, 2005; Maurer and Ebers, 2006; Molina and Martinez 2009, 2010). In order to ask managers about the ***type of relationships maintained with their partners***, the following ten items were used: SC1: We share the same goals and interests in

[3] The results are comparable to the completely same operationalization of alliance partner diversity used in these other studies, which was analysed as a robustness check.

joint projects. SC2: We are motivated to pursue collective goals in joint projects. SC3: There is a shared vision on the environment and the key factors of success. SC4: We believe that the future of our company is related to companies with whom we have established an alliance. SC5: We have developed some type of strategy or common plan for joint projects. SC6: We trust that the companies with whom we are in partnership do not take advantage of the alliance or behave opportunistically. SC7: Companies with whom we have the alliance maintained the commitments made. SC8: We are sure that there will be agreement, even when there is not a written contract that specifies the obligations of each party. SC9: In general, there is a climate of cooperation and mutual trust among the participants. SC10: We feel a special obligation to be supported in difficult situations and to support each other. An exploratory factor Analysis (EFA) supports the convergent and discriminant validity of this measure. Cronbach' alpha is 0.89 proving the high reliability of this scale. As it can be seen in Appendix 1 Relational social capital was loaded onto a separate factor with eigenvalues greater than 1 (5.57) accounting for 55.66 percent of the total variance.

Knowledge codifiability was measured using our own items adapted from Kogut and Zander (1995) and Subramaniam and Venkatraman (2001) scale. The five items for this dimension of the ***characteristics of the knowledge used in the development of innovations*** were: KC1: There exists a useful manual that describes the processes. KC2: The information and decision rules are stored in electronic databases. KC3: Knowledge about the alliance is sufficiently explained in writing. KC4: New staff can learn easily talking to staff involved in the alliance. KC5: New staff can learn easily by studying the existing manual. An exploratory factor Analysis (EFA) supports the convergent and discriminant validity of this measure. Cronbach' alpha is 0.82 proving the high reliability of this scale. As it can be seen in Appendix 1 Knowledge Codifiability was loaded onto a separate factor with eigenvalues greater than 1 (3.10) accounting for 62.01 percent of the total variance.

3.2.3. Control variables

Firm size was measured by the total number of employees reported by firm's respondents**.** ***R&D intensity*** was measured by dividing the numbers of permanent employees in the R&D department by total number of employees. ***Age*****:** following Sørensen and Stuart (2000), we also controlled for firm age (2013 – company foundation date). ***Leader*****:** we have considered relevant to control for who the leader of the alliance is; this is a dummy variable, with 1 if the observed firm is the leader of the alliance and 0 if not. We have also controlled for the different ***clusters*** used in the analysis (Andalusia, Catalonia, Valencia, Basque Country and Madrid).

4. ANALYSES AND RESULTS

Given that the measurement scales used were based on an exhaustive review of the relevant literature concerning the constructs under study, we can affirm their content validity. As we have just explained, an exploratory factor analysis was performed separately for each construct, using principal component analysis, selecting factors with eigenvalues greater than one. All the items of each construct loaded in only one factor (unidimensionality). Appendix 1 represents the factor analysis for the multidimensional.

With regard to reliability, Cronbach's alpha exceeded the minimum value of 0.70 recommended by Nunnally and Bernstein (1995) for all the multidimensional scales. Thus, these measures seem to be reliable and valid. Table 1 shows means, standard deviations and correlations for the study variables. Concerning correlations, we note that there is a high correlation between innovation performance and relational social capital, between innovation performance and codifiability, and between size and age and age and R&D intensity. To ensure that multicollinearity was not an issue, Value Inflation Factors (VIFs) were computed (but are not reported here because of space limitations). No VIFs were greater than 5, indicating that we did not encounter multicollinearity.

Table 1: Means, standard deviations and correlation matrix

	Mean	s. d.	1	2	3	4	5	6	7	8
1. Age	9,39	9,03	1							
2. Size	66,14	325,82	0,76**	1						
3. R&D Intensity	67,47	30,40	-0,55**	-0,30**	1					
4. Leader	0,76	0,43	-0,13	-0,05	0,20	1				
5. Diversity	0,26	0,14	0,04	0,00	-0,08	0,18	1			
6. Social capital	5,80	0,96	0,05	0,03	-0,02	0,17	-0,17	1		
7. Codifiability	4,82	1,31	0,10	0,10	-0,05	-0,01	0,17	0,22*	1	
8. Innovation Performance	5,62	0,89	0,15	0,10	-0,13	-0,04	-0,26*	0,66**	0,37**	1

† p < .1; * p < .05; ** p < .01; *** p < .001; The correlation coefficients are two-tailed tested. N=90.

Our hypotheses were tested using hierarchical regression analysis because an interaction effect only exists if the interaction term gives a significant contribution over and above the direct effects of the independent variables (Cohen and Cohen, 1983).

The results are displayed in Table 2. The base model displayed in the first column explains a non-statistically significant share of the variance.

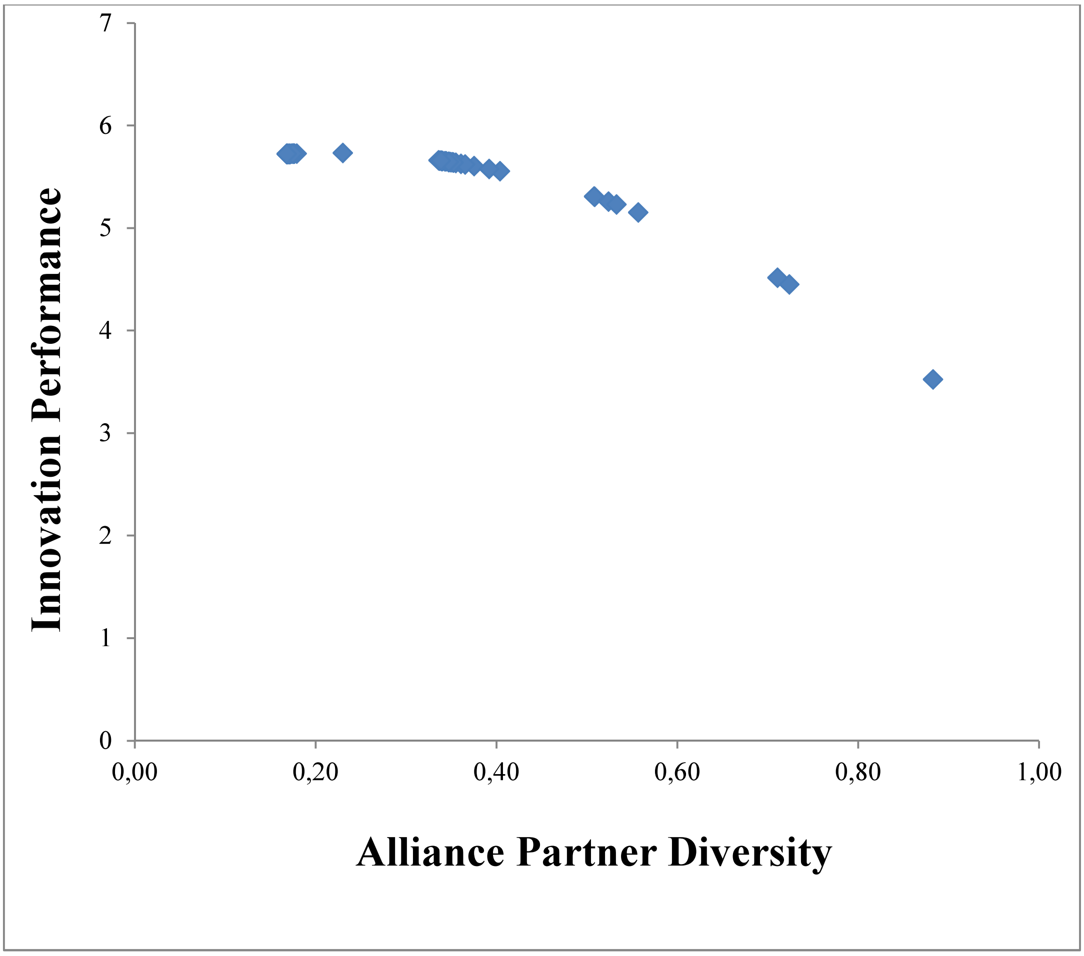
Table 2: Regressions

Dependent variables	Base Model	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	β	β	β	β	β	β	β	β
Control variables								
Cluster1	-0,86 *	-0,89 **	-0,82 *	-0,28	-0,28	-0,26	-0,28	-0,31
	(0,34)	(0,32)	(0,32)	(0,25)	(0,26)	(0,25)	(0,25)	(0,25)
Cluster2	-0,85 *	-0,83 *	-0,85 *	-0,16	-0,16	-0,15	-0,16	-0,24
	(0,35)	(0,34)	(0,34)	(0,27)	(0,27)	(0,26)	(0,27)	(0,27)
Cluster 3	-0,87 *	-0,88 *	-0,80 *	-0,46	-0,46	-0,40	-0,46	-0,45
	(0,40)	(0,39)	(0,38)	(0,29)	(0,29)	(0,28)	(0,29)	(0,29)
Cluster 4	-0,75 †	-0,75 †	-0,77 *	-0,29	-0,30	-0,25	-0,30	-0,36
	(0,40)	(0,38)	(0,38)	(0,29)	(0,30)	(0,29)	(0,29)	(0,29)
Age	0,01	0,02	0,02	0,01	0,01	0,01	0,01	0,01
	(0,02)	(0,02)	(0,02)	(0,01)	(0,01)	(0,01)	(0,01)	(0,01)
Size	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)
R&D	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)	(0,00)
Leader	0,10	-0,06	-0,10	0,13	0,13	0,17	0,13	0,11
	(0,23)	(0,23)	(0,23)	(0,17)	(0,17)	(0,17)	(0,17)	(0,17)
Main effect variables								
Diversity		-1,79 **	2,12	-0,19	0,17	-18,61 *	0,61	26,81 †
		(0,65)	(2,36)	(1,78)	(4,48)	(9,12)	(3,36)	(14,93)
Diversity^2			-4,95 †	-1,45	-1,60	22,13 *	-1,34	-47,00 †
			(2,87)	(2,18)	(2,75)	(10,47)	(2,23)	(25,47)
Social Capital				0,50 ***	0,51 **	-0,03	0,50 ***	0,51 ***
				(0,08)	(0,16)	(0,28)	(0,08)	(0,08)
Codifiability				0,20 ***	0,20 ***	0,19 ***	0,24	0,82 *
				(0,05)	(0,05)	(0,05)	(0,15)	(0,36)
Interactions								
Div X CS					-0,05	3,68 *		
					(0,53)	(1,67)		
Div^2 X CS						-4,86 *		
						(2,07)		
Div X Cod							-0,17	-4,99 †
							(0,61)	(2,74)
Div^2 X Cod								8,42 †
								(4,68)
Model								
R^2	0,11	0,18	0,21	0,58	0,58	0,61	0,58	0,60
Adjusted R^2	0,02	0,09 *	0,11 *	0,51 ***	0,51 ***	0,53 ***	0,51 ***	0,52 ***
F statistic	1,21	2,00	2,14	8,79	8,01	8,27	8,02	7,90
^R^2		0,08 **	0,03 †	0,37 ***	0,00	0,03 *	0,00	0,02 †
Change in F		7,51	2,96	33,32	0,01	5,49	0,08	3,24

Two-tailed tested. † $p < .1$; * $p < .05$; ** $p < .01$; *** $p < .001$; *** High-performance work practices; Standard errors in parenthesis.

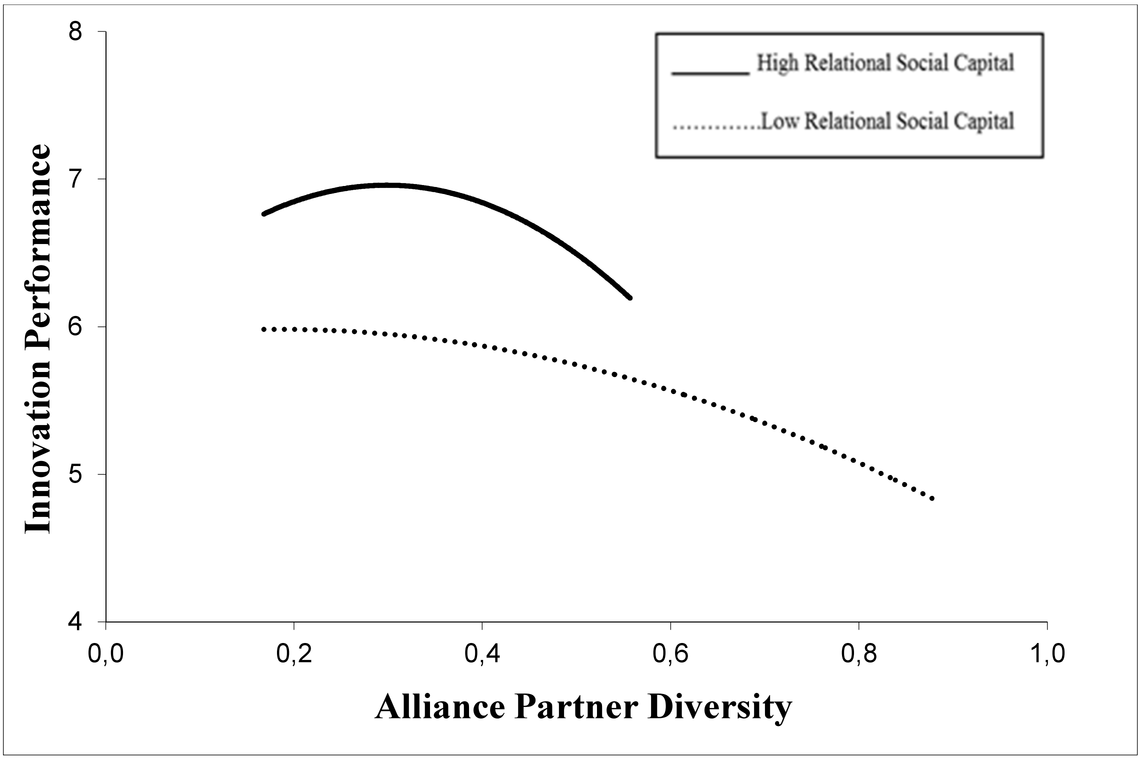
Model 1, in the next column, makes a significant contribution over and above the base models ($\wedge R^2 = 0.08$, $p < 0.01$). Here, we can see that alliance partners' diversity has negative influence on innovation performance. Model 2 makes a significant contribution over and above the base models ($\Lambda R^2 = 0.03$, $p < 0.10$). The regression coefficient for the inverted U-shape relationship between alliance partner diversity and innovation performance ($\beta = -4.95$; $p < 0.10$) is significant. Therefore, we find support for hypothesis one. However, caution should be taken in moment to interpret results of relationship between alliance partner diversity and innovation performance as we do not have sufficient observations before the optima (turning point), thus following Lind and Mehlum (2010) three-step procedure we can only confirm the first step. Nevertheless we performed additional analyses taking different measure for alliance partner diversity used in previous studies (Oerlemans et al., 2013; de Leeuw et al., 2014) what we include in the Appendix 2 where the results are similar. Moreover, as Haans et al. (2015) suggest as a robustness check we added a cubic term (X^3) to conducted model 2 and what we found is that the cubic term of alliance partner diversity did not improve model fit hence we may confirm that observed relationship is indeed quadratic (see Appendix 3). Figure 2 represents the plotted effect between squared diversity and innovation performance.

Figure 2: Curvilinear relationship between alliance partners diversity and innovation performance



Next, the two moderator variables were entered. Model 3 makes a significant contribution over and above the base models ($\wedge R^2 = 0.37$, $p < 0.00$). Table 2 shows that both relational social capital and knowledge codifiability have a positive influence on innovation performance. The two interactions were entered separately for each dependent variable, as recommended in the literature (Cohen and Cohen, 1983). As authors as Phelps (2010) suggested, in order to analyse curvilinear effects, each moderation should be included in a separated model. The first interaction, the one between diversity and relational social capital, is reported in Model 5 and makes a significant contribution over and above the main effects ($\wedge R^2 = 0.03$, $p < 0.05$). The regression coefficient for the interaction between squared diversity and relational social capital ($\beta = -4.86$; $p < 0.05$) is significant. To determine the nature of the significant interaction, we plotted the effect diversity on the dependent variable for values of the relational social capital set at the mean and one standard deviation above and below the mean, as suggested by Cohen and Cohen (1983). This plot is reported in Figure 3.

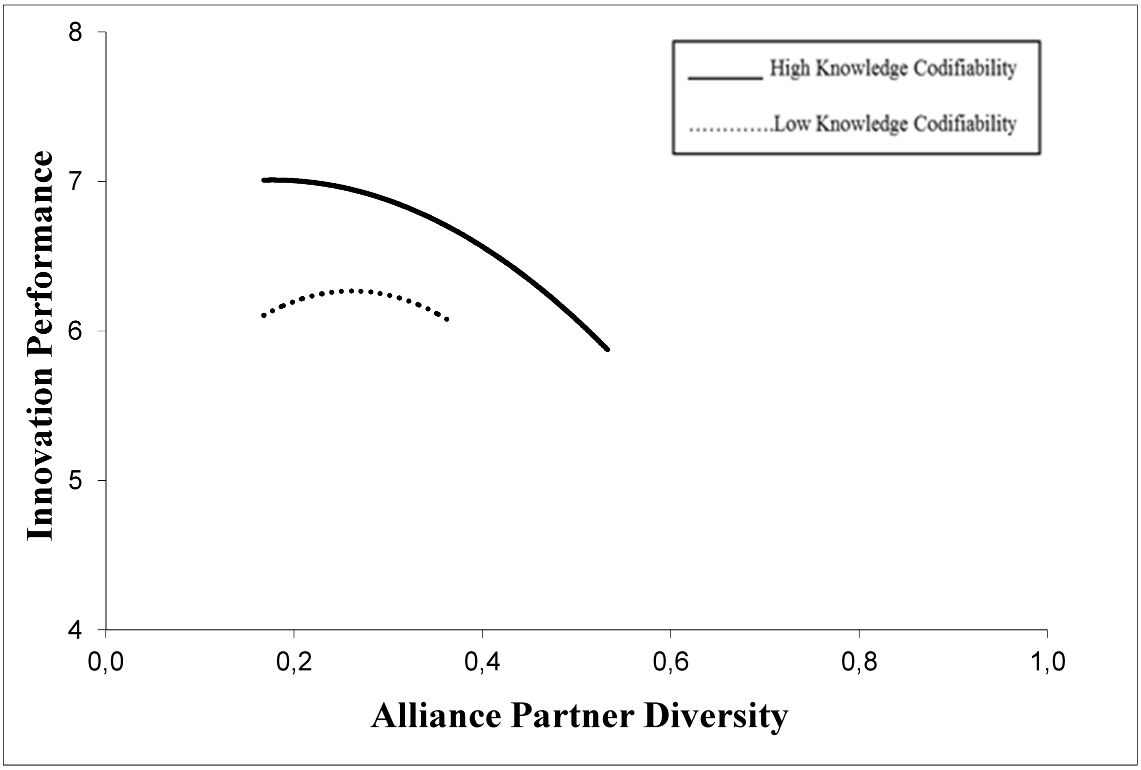
Figure 3: Interaction between relational social capital and diversity



The first curvilinear interaction model attempts to validate the existence of a nonlinear relationship between diversity and relational social capital over innovation performance. Figure 3 shows that this curvilinear relationship appears when it is moderated by relational social capital and, as proposed in hypothesis 2, the relationship is higher when relational social capital is higher. Therefore, we find support for hypothesis 2.

The second interaction, the one between diversity and codifiability, reported in Model 7 makes a significant contribution over and above the main effects ($\wedge R^2 = 0.02$, $p < 0.10$). The regression coefficient for the interaction between squared diversity and codifiability ($\beta = 8.42$; $p < 0.10$) is significant. To determine the nature of the significant interaction, we plotted the effect of diversity on the dependent variable for values of the codifiability set at the mean and one standard deviation above and below the mean, as suggested by Cohen and Cohen (1983). This plot is reported in Figure 4.

Figure 4: Interaction between codifiability and diversity



The second curvilinear interaction model attempts to validate the existence of a nonlinear relationship between diversity and codifiability over innovation performance. Figure 4 shows that this curvilinear relationship appears when it is moderated by codifiability and, as proposed in hypothesis 3, the relation is higher when knowledge codifiability is higher. Therefore, we find support for hypothesis 3.

5. DISCUSSION AND CONCLUSION

Studying alliances for improving innovation performance has become common practice in the research on innovation, especially in intensive knowledge industries. Nevertheless, the literature shows that not all the alliances are equally effective. Thus, the study of why some alliances contribute more than others when it comes to improve performance represents a relevant issue (Sampson, 2007). This paper provides empirical evidence on some characteristics of the alliances that determine high innovation performance.

Our research has addressed the question of how the diversity of the partners in a certain alliance for innovation affects innovation performance, and how this influence can be moderated by certain characteristics of the alliance, such as the relational social capital and type of knowledge shared among partners.

Our results suggest a curvilinear relationship between alliance partner diversity on innovation performance, similarly to previous literature that highlights the opportunities and hindrances of diversity (de Leeuw et al., 2014; Duysters and Loksing, 2011; Laursen and Salter, 2006; Sampson, 2007; Oerlemans et al., 2013). Although we have not been able to strongly confirm the inverted u-shaped relationship, the idea that a very low as well as a very high level of alliance partner diversity can be detrimental for the performance of the alliance makes sense. If the level of partner diversity in the alliance is very low, knowledge stocks may overlap too much and innovation may be inhibited, since possible new combinations of existing knowledge may have been exhausted (Sampson, 2007). In the opposite extreme, very diverse partners in the alliance, while providing greater access to diverse information, also involve ineffective communication and coordination, reducing the ability to use the diverse knowledge to which they have access (Phelps et al, 2012). Thus, as we expected, it seems that firms can reap more benefits from their innovation alliance when the level of alliance partner diversity is moderated.

In spite of the logic of this reasoning, our results also suggest that the influence of alliance partner diversity on innovation performance is even more complex than the inverted U-shaped effect we had proposed. In this sense, it should not be considered in isolation but in interaction with other features of the alliances.

Regarding relational social capital, we demonstrate that its interaction with alliance partner diversity improves the innovation performance of the alliance. We proposed that relational social capital (in the sense of close and trustful relationships among partners) can leverage the benefits of diversity by helping to reduce the difficulties when exchanging very diverse knowledge as well as by mitigating the fear of opportunistic behaviour. Thus, what our results suggest is that firms that trust their partners in their alliances are more willing to make efforts to share, receive and understand knowledge that is dissimilar to what the firm already knows. At the same time, in alliances comprised of diverse partners, problems associated with information asymmetry are likely to emerge. In this sense, relational social capital in the alliance would create a normative context that would reduce the fear of disloyal behaviours among partners.

The specific shape of the diversity-relational social capital interaction effect (an inverted U) also deserves attention. When relational social capital is considered, the influence of diversity on performance is as originally expected; that is, a moderate degree of alliance partner diversity is what best contributes to the achievement of high innovation performance. Beyond a certain level of diversity, innovation performance decreases. What is important to highlight here is that when there is a high level of relational social capital in the alliance, the performance is always higher than for a lower level of relational social capital.

Regarding the moderating effect of knowledge codifiability, our results show that alliance partners' diversity can improve innovation performance when the alliance partners share codified knowledge. As we suggested, it seems that codifiability can help reduce the complexity of knowledge transfer among diverse partners by facilitating that all of them receive the same information without loss of meaning. All this makes such complex relationships more effective and simple. Only a common understanding of the knowledge that is being shared and transferred among diverse partners may contribute to improve the innovation performance of the alliance. Even so, and similar to relational social capital, while knowledge codifiability always improves the diversity-performance relationship for both high and low levels of knowledge codifiability, moderate levels of alliance partners diversity get higher results.

Moreover, our study provides some interesting findings. Our results reflect the point that when moderator variables are included into the model, the baseline relationship between alliance partner diversity and innovation performance disappears. This is emphasizing that the relational social capital and knowledge codifiability are relevant variables to consider when studying innovation performance of biotech companies.

Our research contributes to the literature in different ways. First, we provide insights about the role of diversity in the specific context of alliances for innovation in the biotech industry. Given that diversity of partners entails both opportunities and disadvantages, research on this topic has provided heterogeneous results, and the necessity of a common understanding of the impact of alliance partners' diversity on performance has been claimed (Goerzen and Beamish, 2005; Wassmer, 2010). Be that as it may, one could think that the effect of diversity is mainly dependent on the specific context in which the alliance occurs as well as the type of outcome that is being considered. More specific studies can help gain better understanding of how this alliance attribute contributes to better performance. Thus, in the biotech industry (characterized by a high number of small and young knowledge-intensive firms that are highly clusterized and specialized in a specific area of science) a moderated level of diversity increases innovation performance. Besides, research on alliance partner diversity, as determinant of alliance performance, should take into account other variables to understand why some companies better benefit from diverse alliances.

Previous research had already explored how diversity interacts with the alliance organization (Sampson, 2007) and with some firm capabilities and tools (Duysters et al., 2012; Oerlemans et al., 2013; Terjesen et al., 2011), which can be seen as conscious and targeted managerial efforts (Oerlemans et al., 2013). Our research demonstrates that some intrinsic characteristics of the alliances (how the relationships among partners are and what type of knowledge they share) also help to explain the role of diversity in the alliances for innovation in the context analysed. Both relational social capital and codified knowledge leverage the benefits of having diverse partners.

6. Managerial implications and limitations

Some relevant managerial implications can be derived from our research. Firms involved in alliances for innovation must be aware of the fact that diversity has to be appropriately managed in order to reap the benefits of sharing knowledge with different partners. Besides other tools and capabilities that firms can deploy, managers should monitor other intrinsic characteristics of the alliance. Promoting close and trustful relationships among partners and making efforts to codify the knowledge to be shared will help to reduce usual problems associated with diversity.

Managers must also be aware that these beneficial effects of diversity, relational social capital and codified knowledge working together are not unlimited. If the alliance is comprised of partners that are too diverse, problems of coordination, difficulties for understanding very heterogeneous knowledge and fear of opportunistic behaviour, may not be reduced by these attributes of the alliance.

This research has some limitations. First, other variables not included here could explain the complex issue of innovation performance. Furthermore, given the complexity of issues such as knowledge and relational social capital, other characteristics could be taken into account. Second, the Spanish sample does not guarantee that the results obtained can be generalized to other countries. Even more, taking into account that we only have 90 observations, it could be thought that increasing the sample could reinforce our findings. Third and finally, the use of cross-sectional analysis provided results at just one point in time, and thus longitudinal studies would be necessary to clarify whether our results change over time.

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CHAPTER III

THINK LOCAL, CONNECT GLOBAL? ALLIANCE PORTFOLIO CONFIGURATIONS AND THEIR IMPACT ON THE PERFORMANCE OF BIOTECH SMES

1. INTRODUCTION

A large body of literature considers that strategic alliances while enabling organizations to exchange valuable knowledge resources and share costs and risks are vehicles for the innovation (Hagedoorn, 1993; Gulati, 1998; Dooley and O'Sullivan, 2007). In high-tech industries, such as biotechnology, knowledge and resources are distributed across a variety of organizations: knowledge generating institutes, small biotech firms, large pharmaceutical companies, and so on (Hendry and Brown, 2006). The costs of new product development and the acquisition of the required knowledge and skills are difficult to assume by a single company (Powell and Brantley, 1992; Hagedoorn, 1993). Because of that, the biotech industry is characterized by the existence of multiple inter-organizational agreements among different types of partners.

Nevertheless, not all alliances are formed for the same purposes and not all of them are equally effective. Thus, understanding how certain characteristics explain the performance of alliances in high technology industries has become a relevant question. In this study, we examine whether and how alliance portfolio configuration determines innovation activities in the biotech industry. Despite the fact that there is an ongoing debate how different types of collaborations influence firms' innovative performance (Baum et al., 2000; George et al., 2002; Al-Laham et al., 2010; Love et. al, 2014) and also the role of the geographical proximity for innovation performance has been addressed in various streams of the literature (Zaheer and George, 2004, McCann and Folta, 2011, Ozer and Zhang, 2015), to our knowledge prior research has not examined altogether differences in type of alliances, locations of their partners and performance simultaneously. Moreover, regarding to Wassmer (2010) extant literature is still scant in offering a fruitful approach that jointly examines the size of alliance portfolio and the mix of a two-dimensional constructs of certain attributes of alliances and partners. The scarcity of empirical evidence on overall characteristics of alliance portfolio configuration that influence performance (Sampson, 2007; Wassmer, 2010) has prevented researchers from understanding how the portfolio of alliances can effectively contribute to innovative performance and growth of the companies. Present study addresses central questions about the effect of alliance portfolio size, type of alliances, their geographical proximity and international orientation on knowledge generation and innovativeness to achieve growth of small and medium biotechnology firms.

Therefore, the aim of this paper is threefold. First, we examine the importance of R&D alliance portfolio size on firm performance. Second, we examine how different types of alliances in portfolio affect firm performance. Third, we explore to what extent the geographic proximity as well as international orientation of alliances' partners matter for development of innovation and growth of the firm. Three facets of firm performance are considered. Scientific performance is reflected by the total number of high quality publications. Technological performance is measured by the development of biotech patents. Economic performance is considered as growth in turnover.

The empirical analysis of a sample of 79 Spanish biotech firms shows that it is not the size of alliance portfolio in itself, but rather its nature that drives technological performance, which in turn has positive influence on firm's growth. More specifically, positive effects of alliances with (local) knowledge generating institutes and an international dimension within alliance portfolios are revealed. Furthermore, it is shown that both scientific and technological developments are contributing to the economic growth of biotech companies. These findings contribute to open innovation and alliance literature by providing as complete as possible insight on how overall characteristics of R&D alliance portfolio configuration improves innovation and impact it has on three different types of performance. Our study also provides empirical evidence that may have implications on management of the companies and their strategic decisions about optimal way of alliance portfolio configuration that enables efficient knowledge exchange for innovation to achieve greater performance.

The remainder of this paper is structured as follows. The next section presents the relevant literature and theoretical background that led to the advanced research propositions and hypotheses. The subsequent sections present the empirical framework used for hypothesis testing, as well as the analytical results. The paper ends with an outline of the conclusions, whereby its contributions, limitations and future line of research are presented.

2. THEORETICAL BACKGROUND AND HYPOTHESIS

Alliances are complex organizational forms involving the transfer of resources between organizations with diverse knowledge and capabilities. It is widely recognized that alliances are an important source of knowledge exchange that is essential in the race for development of new scientific knowledge and technological patents (Powell, 1998; Powell et al., 2005). Even more relevance is given to alliances in the knowledge-intensive industry such as biotechnology where knowledge and resources are broadly distributed and multiple alliances are required to satisfy the company's needs to generate new knowledge and innovations. Thus, biotech firms maintain simultaneously more than one alliance forming their portfolio. Following Wassmer (2010) we defined alliance portfolio as firm's ongoing as well as past strategic alliances. For the purpose of our study, we consider only R&D alliance portfolio related to those alliances that have research, development and innovation goals identified in their scope of activities. R&D alliances are seen as an important way to gain strategic competencies and contribute significantly to innovativeness of focal firms in this industry (Powell et al., 1996; Hoang and Rothaermel, 2010).

Several studies have indicated that a firm's alliance portfolio influences its behaviour and outcomes (e.g., Powell et al. 1996; Ahuja 2000; Baum et al., 2000; Faems et al., 2005; Lavie, 2007; Phelps, 2010; Lahiri and Narayanan, 2013). Powell et al. (1996) discuss "learning through networks" in biotechnology-based clusters. They argue that when knowledge is broadly distributed, the locus of innovation is found in networks of inter-organizational relationships. The knowledge base of biotechnology industry is both complex and expanding and the sources of expertise are widely dispersed what leads to state that collaborations in the biotechnology reflects a fundamental and penetration interest for access to knowledge. The combinations of inter-disciplinary or inter-functional areas contribute to better performance and innovation and can be used to leverage heterogeneity of knowledge in the generation of new ideas.

However, in spite of the growing consensus that such interorganizational networks matter, the specific effects of the different features of an alliance portfolio on organizational performance remain unclear (Ahuja 2000; Wassmer 2010). Thus, the effect of an alliance portfolio on individual firm performance is still a critical question for both managers and scholars (Dyer and Singh 1998; Koka and Prescott 2002; Wassmer 2010).

2.1. Alliance portfolio size and innovation performance

Impact of alliance portfolio size on firms performance has been studied in various theoretical lenses such as the resource-based view of the firm (Ahuja, 2000a; Baum et al., 2000; Zaheer and Bell, 2005), social network perspective (Burt, 1992; Gulati, 1999; Ahuja, 2000a; Baum et al., 2000; Stuart, 2000; Koka and Prescott, 2002; Goerzen and Beamish, 2005) and organizational learning literature (Rothaermel, 2001; Kale et al., 2002; Faems et.al, 2005; Lavie and Rosenkopf, 2006). Given that alliances boost firms' knowledge, those firms that have many alliances are likely to be more innovative (Baum et al., 2000).

Thus, in previous literature it has been argued that having a large number of alliances positively affects firm performance (Deeds and Hill 1999; Baum et al. 2000; Oliver 2001; Owen-Smith and Powell 2004). Regarding Ahuja (2000a) number of a focal firm's direct ties is positively related to the firm's performance. Lahiri and Narayanan (2013) studying manufacturing alliance found that alliance portfolio size enhances financial performance in two ways directly and indirectly by means of vertical scope of the firm. The more firm engage in interogranizational collaborations the more likely it is to create the effectiveness of innovative outcomes as Faems et al., (2005) showed in terms of the proportion of turnover realized by means of new or improved products. Based on these previous studies, it can be expected that, in general, having a large number of alliances positively affects firm's performances.

Hence, we hypothesize that:

Hypothesis 1: Size of the focal firm's alliance portfolio has a positive impact on its performance.

Moreover, different types of alliances with spatially distant partners will involve different degrees of complexity in order to achieve effectiveness in knowledge exchanges hence studying simultaneously these features in alliance portfolio configurations may help to better understand their performance and explain the differences among firms.

2.2. Types of alliances and innovation performance

According to Koza and Lewin (1998) strategic alliances are studied in the context of the adaptation choices of a firm. In other words, innovative firms seek external networks to oppose the trade-off between exploration and exploitation (March, 1991); especially, firms in the biotechnology sector, which represents collaboration across many disciplines, are therefore likely to make different types of partnerships.

Rothaermel and Deeds (2006) state that firms tend to engage in alliances with different partners along the industry value chain, reflecting different types of knowledge being transferred in the alliances. Alliances with universities and research institutions involve a high uncertainty, given the tacit, ambiguous and complex nature of the knowledge transferred, and tend to produce radical innovations. Alliances with industrial partners, being those customers, suppliers and other complementary firms imply the exchange of knowledge that tends to be more explicit and codifiable, given that the other firm provides manufacturing capabilities, regulatory know-how, market knowledge and access. These alliances tend to result in incremental innovations. Thus impact that alliance portfolio has on performance depends on types of R&D alliances it is composed. In line with several studies of firm's strategic alliances research (Lavie and Rosenkopf, 2006; Rothaermel, 2001; Rothaermel and Deeds, 2004; Faems et al., 2005; Gilsing and Nooteboom, 2006) we make a distinction between exploration-based and exploitation-based alliances which reflect their intent to leverage different types of knowledge along the value chain.

During the product development process different stages motivate different types of searches. As a result firms entry into different types of alliances and in this way they collaborate in the market for know-how. Rothaermel and Deeds (2004) in fact concur that in the early stages of a development project of biotechnology, a venture undertakes exploratory search trying to discover something new. This search is often structured through exploration alliances. The same authors viewed the new product development process as a knowledge management process which allows us to expect that the outcome of knowledge transfer will be the embodiment of new knowledge learned through exploration what makes it a prototype product that can be extended into the testing and development process. Indeed, we may consider that exploration alliances by providing patents may lead to the codification of new knowledge and development of technology. Previous literature argued that the motivation for exploration-based collaborations of biotechnology companies is a desire to obtain basic knowledge that can be used to create new molecular entities later included into the development and regulatory process (George et al., 2002; Rothaermel and Deeds, 2004).

Therefore, it can been said that exploration is getting more importance during the discovery phase when the venture follow an exploratory search through basic research, development and risk-taking activities intending to create new capabilities with aspiration of developing new knowledge or qualifications. Gilsing and Nooteboom (2006) define the alliances between biotechnology firms and knowledge generating institutes as networks of exploration which could provide all exploration benefits for the firms. Principally relationships between firms, universities and other knowledge generating institutes are based on the need to access unique resources, expert knowledge and technology that is critical to the technological performance and industry's survival (Liebeskind et al., 1996). In this line the analysis of the young biotechnology industry highlighted the role and importance of "star" scientists for dedicated biotechnology firms (DBFs). Zucker et al. (1998) showed that in early phase of this industry having highly talented individuals was crucial for the innovation process as they are able to shift a radical knowledge base from one scientific paradigm to another to achieve a product of biotech innovation with "competence destroying" nature. With the maturation of the industry, established firms continue to count on universities to be a source for updating information on discoveries and supervising their scientific techniques (Levitte et al., 2010) as the purpose of these alliances is to embody innovative scientific discoveries into the biotechnology firm's products or processes (George et al., 2002). Moreover, having a high profile scientist in a company's stock can raise its price and also increase its credibility among the scientific community (Levitte et al., 2010). Oliver and Liebeskind (1998) have seen collaborations with scientific partners as a primarily support for knowledge exchange and commercialization in the form of intellectual property rights which are crucial for the commercial development.

Similarly, Al-Laham et al. (2010) found, using the argument of relative absorptive capacity (Lane and Lubatkin, 1998), positive influence on patenting when biotech firms engage in collaborative agreements with public research organization as they share similar basic knowledge and different specialized knowledge. This dissimilarity in their operational knowledge may allow to companies to achieve successful conversion of scientific knowledge produced in exploration alliances in commercial products.

Previous studies indicate that collaborations with knowledge generating institutes in biotechnology increase patenting productivity (Zucker et al., 2002). These alliances dedicated to exploration also allow firms to access scientific knowledge from publications and patented inventions for commercialization purposes (George et al., 2002; Al-Laham et al., 2010; Levitte et al., 2010). Besides Faems et al. (2005) found that exploration alliances are positively associated with turnover in terms of developing new technologies and/or products while collaborations with customers and suppliers, labelled as exploitation alliances will produce higher levels of turnover related to improved products. Wuyts et al. (2004) report that interfirms R&D alliances can enhance both a firm's radical and incremental innovation. Both of these innovations reflect exploratory and exploitative learning by firms as a result of interorganizational relationships.

While the intent behind entering an exploration alliance involves a desire to discover new opportunities, an exploitation alliance involves the joint maximization of complementary assets (Koza and Lewin, 1998, p. 257). Alliances and other collaboration agreements with customers leads innovative firms to a better understanding of clients' needs and, as a consequence, to a new product/service solution better adapted to their requirements (Carmona et al., 2013). This has been traditionally named as need-pull innovation (vs knowledge push innovation that would come from alliances with research institutions), which tend to produce improvements in the current products rather than breakthroughs. Exploitative-oriented collaborations could support the improvement and further development of existing technologies and products (Faems et al. 2005). The familiarity of the industrial firms with the new product reduces its complexity, or the degree to which innovation is perceived as difficult to understand and use (Rogers, 1995; Tornatzky and Klein, 1982) and, in turn, the perceived risk of innovation is also reduced (Holak and Lehmann, 1990). All of that has a positive effect on its rate of adoption and the innovation success, measured by the new product profitability (Calantone et al., 2006).

In addition, breadth in the types of information sources that firms utilize, such as knowledge from customers (Urban and von Hippel, 1988) and suppliers (Leiponen, 2000), is likely to affect innovation outcomes (Rosenkopf and Nerkar, 2001; Laursen and Salter, 2006; Leiponen, 2012).

Previous studies suggests that innovative firms rely heavily on their interactions with customer and suppliers (Urban and von Hippel, 1988; Szulanski, 1996; Leiponen, 2012) highlighting the exploitative character of the innovation process. Regarding to Al-Laham et al. (2010) there is a positive relationship between biotech alliances with pharmaceutical partners and patent rate. Leiponen (2012) studied manufacturing and service industries highlight the relevance that customers and suppliers have for access to new informations and ideas for innovation. Firms' innovation activities are strongly determined by relations between themselves and their suppliers and customers (Laursen and Salter, 2006). The same authors found that this relationship is positively significant for radical and well as for incremental innovation. They also claimed that in early stages of product life cycle only a few actors may have knowledge of the key technologies underlying the evolution of the products and firms can benefit from exploitative alliances to get sources for innovation and technological development. In exploitation alliances, firms can leverage complementary assets and the partner's resource endowments.

Hence, alliances with customers and suppliers facilitate the exploitation of knowledge gained from other sources by allowing the firm to access partner stocks of knowledge in order to exploit complementarities. Regarding to Hoang and Rothaermel (2010) firms in exploitation alliances are matching specialized complementary resources and skills that leads to significant reduction of costs as operational knowledge base is close within industrial partners (Al-Laham et al., 2010). Lower effort and costs, especially in the managerial attention required to coordinate and leverage external exploitation, allow firms to focus on its area of specialization and increase alliance performance (Hoang and Rothaermel, 2010). Thus simplified learning benefits from exploitative alliance may positively influence performance of biotech companies.

Accordingly, we propose the following:

Hypothesis 2a: Exploration-based alliances have a positive effect on the performance of focal firm.

Hypothesis 2b: Exploitation-based alliances have a positive effect on the performance of a focal firm.

2.3. Geographic proximity of alliances' partners and innovation performance

According to Gertler and Levitte (2005) the literature on biotechnology innovation and interactive learning has tended to emphasize the importance to inter-firm collaboration and knowledge flows in local context as the principal source of technological dynamism. More recently appears alternative approach (Cooke, 2004; Zaheer and George, 2004; Gertler and Levitte, 2005) which gives the importance to non-local knowledge flows. This view reflects that truly dynamic economic regions are characterized both by dense local social interactions and knowledge circulations, as well as strong inter-regional and international connections to outside knowledge sources and partners.

Geographical proximity is generally assumed to facilitate knowledge exchange, particularly when knowledge is complex and has a strong tacit component (Zucker et al, 2002). However, it has also been argued that the relevance of geographical proximity lies mainly in the fact that co-location favours the development of other types of proximity – social, cognitive, organizational – which are the effective enablers of knowledge exchange (Boschma, 2005); and which can persist even after co-location ceases (Bathelt et al, 2004). The presence and persistence of these types of proximity may also contribute to support processes that involve knowledge exchange at a distance, which is recognized to entail greater difficulties (Bathelt et al, 2004).

It has been shown that in industries where knowledge is highly tacit, a clustered network structure through geographical proximity of partners facilitates the flow of knowledge (Cooke, 2004). Much sophisticated technical knowledge required to generate innovation in knowledge-intensive industry is tacit in character – a permanent mix of design, process and expertise. Such knowledge and information is not easily transferred by license or acquisition. The recipients need to be actively involved in research process. Zucker et al (1998) have noted that especially in the early phases of the exploitation of biotechnology the successful development required considerable amount of tacit knowledge, which again often requires short distance or face-to-face interaction to be created and transferred.

The commonality of organizational routines, facilitated by proximity, makes for easier absorption and interpretation of knowledge gained through the mechanisms. Common context can create an environment of trust between firms and individuals, thus, enhancing the utility of the mechanisms of knowledge flows. For instance, geographic proximity enables more face-to-face interaction that helps in the building of trust between individuals (Porter 1991). Similarly, the network literature suggests that social networks within regions facilitate repeated interactions and the development of trust, thus, enhancing local knowledge flows through alliances and mobility (Coleman 1990, Walker et al. 1997). The favour situation for knowledge exchanges among local firms is that the work practices, culture, and even technical terminology are often peculiar to a region and vary dramatically across regions. This common context increases the likelihood of similarity between firms in terms of their practices and routines which in return make the interfirm knowledge exchanges within cluster firms more attractive (Rosenkopf and Almeida, 2003).

In biotechnology, local connections between industry and university are far more prevalent than in any other sectors (Levitte et al, 2010). Universities are starting many technology ventures either by spin off or scientists become entrepreneurs in cooperation whit venture capitalists. Those new ventures, in their early stages, normally rely on exploration cooperation with their original organization. Especially in the early phases the localization effects seem originate because the so called 'star scientists' that are invaluable to R&D activities tend to locate near their home universities (Zucker et al 1998). McCann and Folta (2011) found that firms' local exploration alliances have positive effect on firms' patenting performance. Moreover, they suggested that policy makers should take actions such as building stronger relations with local universities and firms because collaboration between them may enhance innovation performance of firms which will in turn enrich knowledge of the region.

Local collaborations constitute a conduit that channels the flow of information and know-how among firms in the network (Ahuja, 2000). In these networks the member firms acting as both a recipient and transmitter of information. According to Ahuja (2000) the structure of these networks greatly influences the dynamics of information diffusion within the networks. Similarly, Ozer and Zhang (2015) showed that by maintaining ties with customers and suppliers from the same regional cluster firms enhance their exploitative product innovation. Located in the same spatial cluster firms develop similar language, technology attitudes and interpretative schemes (Lawson and Lorenz, 1999) which facilitate the knowledge exchanges through collaborations for innovation and enhance the performance. In geographical clusters proximity makes information about local competitors more available because managers are better able to scan the activities of local competitors compared to the activities of spatially distant competitors. Frequent social and professional interactions and recruitment from a common, highly mobile professional labour pool would lead to a high level of information exchange among managers and an awareness of the capabilities of local competitors. Moreover, the local interaction that underlies these forms of information exchange is superior for interpreting social signs, sharing similar organizational culture, and resolving uncertain and ambiguous issues.

In line with the previous, we propose that:

Hypothesis 3a: Local exploration-based alliances have a positive effect on the performance of a focal firm.
Hypothesis 3b: Local exploitation-based alliances have a positive effect on the performance of a focal firm.

2.4. International Orientation of alliances' partners and innovation performance

In spite of the undeniable benefits of proximity the knowledge, technology, and skills being generated inside the geographical cluster may become a "blind spot" (Pouder and St. John, 1996) given the rapid rate of technological developments and the need to integrate in various streams of technological knowledge in technology-intensive industries. In this case, firms that extend to create formal partnerships outside their geographical clusters are likely to avoid falling into the blind spots and redundancies, leading to higher performance than for firms which collaborate only locally. Pouder and St. John (1996) generally argued that while building of formal ties within the cluster is likely to be beneficial, formal ties outside the cluster are likely to be even more so.

Biotechnology firms benefit also when they extend to form formal alliances beyond their regional agglomerations. This finding is consistent with the logic of structural holes (Burt, 1992) and suggests that all the requisite knowledge that firms need is not necessarily available within their geographical clusters. Firms in knowledge intensive industries need to access the frontiers of technology no matter where they are being ejected. The biotechnology projects are then much more formalized and representing more often on formal scientific knowledge. Considering the spatial pattern of leading biotechnology centres described in Cooke (2004) we might come to the conclusion that global networks are prominent for the biotechnology industry, but they have to be able to ensure the codified knowledge to transfer.

In particular, international networks as global pipelines are often regarded as vital for sourcing new knowledge for innovation (Bathelt et al., 2004). It has been argued that in order to avoid the risk of lock-in, international networks are vital for being exposed to fresh knowledge (Bathelt et al., 2004; Boschma, 2005). This literature originally focused on formal links in the form of global pipelines, or "strategic partnerships of interregional and international reach" (Bathelt et al., 2004). Moreover, embeddedness in global innovation networks affects competitiveness (Kafouros et al., 2012).

Knowledge must be continuously rejuvenating if we expect that the exchanges affect development of technological innovations. Rejuvenate of knowledge can be achievable through interactions with entities outside of cluster because they can bring absolutely new ideas and can allow access to technologies that are unavailable in the region.

Therefore, biotech firms that realize knowledge exchanges with firms outside their geographical clusters, while benefiting from within cluster spill-overs, are also more likely to gain access to new and diverse information, knowledge, and technology, resulting in superior innovativeness (Zaheer and George, 2004). Firms with international orientation by gaining scientific know-how from knowledge generating institutes as well as business partners they access new knowledge and trends available in global market. Firms which are maintaining international partners in their alliances portfolio are more prone to develop technology and growth.

Hence, the following hypotheses are presented:

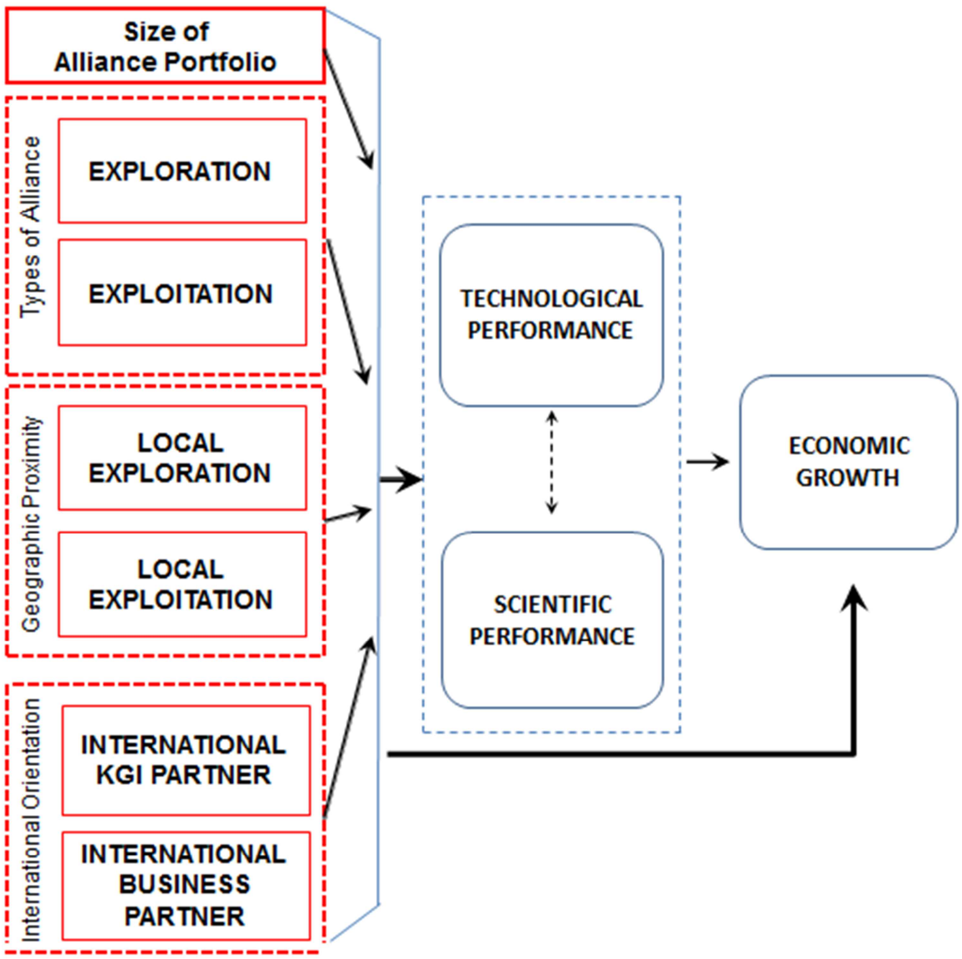
Hypothesis 4a: The presence of international knowledge generating institute partner in firm's alliance portfolio has a positive effect on its performance.
Hypothesis 4b: The presence of international business partner in firm's alliance portfolio has a positive effect on its performance.

To summarize, biotech industry is now considered as a prime example of the local ties and global networks configuration as outlined by Cooke (2004). Biotech firms may benefit from both relationships, inside and outside the cluster. Zaheer and George (2004) argued that maintaining dense ties within the cluster and bridging structural holes outside the cluster are important in biotechnology. Their findings can be interpreted as signifying that firms equally need the benefit from what these two opposing structural patterns provide. The earlier dense ties possibly allowing firms to stay side by side with the current technologies of their customers and suppliers and the latter (structural holes) providing access to diverse and novel technologies.

Finally, Figure 1 captures the theoretical proposition, where direct and indirect expected effects from our study are represented.

Figure 1: Theoretical model:

Impact of alliance portfolio configuration on performance



3. METHODOLOGY

3.1. Research Design and Sample

Biotechnology is in its essence a result of cross-industrial and cross-disciplinary scientific synergies between a wide variety of actors across both public and private sectors. It has been argued in wide variety of the literature that biotech firms tend to cluster (Powell et al., 1996; Oliver and Liebeskind, 1997; Gertler and Levitte, 2005; Chiaroni and Chiesa, 2006; McCann and Folta, 2011) because local linkages provide closely coordination which may be satisfactory for efficient exchange of tacit knowledge and generation of ideas for technological development (Hendry and Brown, 2006). Therefore, in order to test the hypotheses related to our research question, we use a sample of 79 biotechnology firms belonging to five main clusters in Spain: Bioregion (Andalusia), Biobasque (The Basque Country), Biocat (Catalonia), Bioval (Valencia) and Madrid Biocluster. We built the database of companies of these clusters by matching the database of ASEBIO (Spanish Association of Biotechnology Companies) and the information found on the websites of the cluster agencies.

For our research, only companies that have biotechnology as its main activity have been considered, leading to a population of 285 firms. Proposed study in this work required capturing information from both secondary and primary sources. First data were collected through a personal survey during 2012 and 2013. Questionnaires were addressed to the CEO and/or the person responsible for R&D activities, and questions were referred to the portfolio of R&D alliances for innovation that the firm had established in the last five years. After eliminating those cases with missing data, ninety three valid responses were obtained, which provided a usable response rate of 32.6%. To approximate a firm's technological activities, we collected information on firms' yearly patent activities from 2000 to 2012. The patent data is derived from the EPO Worldwide Statistical Patent Database version October 2013 (PATSTAT October 2013 database). Further on, we matched our dataset to SABI/AMADEUS database which provides financial data of Spanish companies. We found necessary information of eighty three companies from our sample. Finally, we used the Web of Science to collect publication data of the companies. The final dataset for this study is composed of seventy nine companies which represents 27.7% of total population.

3.2. Measures

3.2.1. Dependent variables

The dependent variable, ***technological performance***, was coded "1" if a firm has a patent and "0" if has not. We considered patent applications from 2008 to 2012 in USPTO, EPO and JPO patent systems to construct this dichotomous variable. We opted for binary variable to capture technological development as firms from our sample, and generally Spanish firms, are barely patenting their activities. The use of patenting as an indicator of technological innovation is consistent with a large body of empirical studies investigating the nature and geography of innovation in biotechnology (Zucker et al., 1998; Niosi and Bas, 2001; Gertler and Levitte, 2005; Al-Laham et al., 2010).

The second dependent variable, ***scientific performance***, was measured with the total number of publications firm had recorded in Web of Science from 2008 to 2012. Web of Science is the most relevant database which is considering only high quality scientific production.

The third dependent variable in our study is ***economic*** performance expressed as ***growth*** of firm's turnover. We measured this continuous variable through the absolute turnover growth rate over the period 2008 to 2012. More concretely, to calculate the absolute turnover growth rate of whole period, we subtract the turnover from the last observed year to first observed year, thereafter we divide it by the number of years in between. The result is the absolute turnover growth rate of the last five years. The reason why we took the absolute growth rate instead of taking the relative growth rate is the fact that we want to explain real economic performance and relative growth rates could be the same for firms with big differences in amount of turnover, especially in biotechnology sector.

3.2.2. Independent variables

Size of alliance portfolio: measured as total number of alliances firm had in previous five years.

Exploration-based alliances: measured as absolute number of alliances firm had with the knowledge generating institutes.

Exploitation-based alliances: measured as absolute number of alliances firm had with its customers and suppliers.

Local exploration alliances: measured as absolute number of alliances firm had with knowledge generating institutes from the same cluster.

Local exploitation alliances: measured as absolute number of alliances firm had with its customers and suppliers from the same cluster.

Presence of international KGI partner: binary variable (0/1) if firm has at least one alliance with international knowledge generating institute partner in its portfolio of alliances.

Presence of international business partner: binary variable (0/1) if firm has at least one alliance with international business partner (being them customers or suppliers) in its portfolio of alliances.

3.2.3. Control variables

Scientific background: We controlled for the total number of publications firm had in previous period. We used time period from 2000 to 2007 as the period previous to observed one. The reason why we took the natural logarithm of this variable is to reduce the probability that extreme observations would bias our findings.

Previous technological activity: binary variable (0/1) if firm had patent before observed period, also considering the time period from 2000 to 2007.

Part of multinational company: binary variable (0/1) which represents if firm is a part of multinational company.

Size: measured as the natural logarithm of firm's number of employees.

Cluster dummy: In order to control for the different clusters in which companies from our sample are located (Andalusia, Catalonia, Valencia, Basque Country and Madrid) we distinguish between two categories and introduced the dummy variable in the analysis. In terms of context Catalonia and Madrid are significantly more developed regions (with greater number of patents, scientific publications, researcher employees in DBF, etc.) thus the firms which are located in these two clusters are coded 1 and firms form other cluster are 0 coded. We could control for all of them separately but due to the relatively small number of observations we opted for this alternative to avoid bias. Even when we have introduced 4 dummies in the model, in some robustness tests, the results remain pretty the same.

4. RESULTS

Table 1 presents descriptive statistics and correlations for all variables. The correlations show a few possible problems of multicollinearity. Notably, total number of alliances is highly correlated with the number of exploration and exploitation alliances (r > .70); the high correlation is not surprise since these two types of alliances are nested subset of alliance portfolio. Because of the collinearity, we introduced these variables separately in the analysis. Concerning more correlations coefficient, we noted that there is a quite high correlation between other alliance variables (exploration and exploitation alliances and between local exploration and local exploitation alliances). To assess the threat of multicollinearity, we calculated the variance inflation factors (VIFs) for each coefficient. The maximum estimated VIF for was 2.4, well below the recommended ceiling of 10 (for a discussion of these issues see Cohen et al., 2003). Moreover, in an attempt to compensate for a potential simultaneity bias and to allow for potential claims of causality, we performed additional analyses which we reported in appendix 1.

Table 1:
Descriptive statistics and correlations [a]

Variables	Mean	s. d.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Technological Performance	0,38	0,49	1														
2. Scientific Performance	6,66	16,74	0,31**	1													
3. Economic Growth	102,02	271,76	0,46**	0,41**	1												
4. Cluster Dummy	0,38	0,49	0,25*	0,06	0,13	1											
5. Size [b]	2,25	1,02	0,27*	0,38**	0,42**	-0,03	1										
6. Part of MNC	0,11	0,32	0,21	0,23*	0,37**	0,13	0,42**	1									
7. Previous Patents	0,18	0,38	0,39**	0,35**	0,25*	0,05	0,20	0,04	1								
8. Previous Publications [b]	0,30	0,71	0,39**	0,44**	0,51**	-0,01	0,44**	0,42**	0,15	1							
9. Number of Alliances	12,56	15,09	0,23*	0,22*	0,13	0,17	0,29**	0,17	-0,01	0,35**	1						
10. Exploration Alliances	6,08	7,94	0,30**	0,15	0,08	0,09	0,27*	0,05	0,04	0,32**	0,93**	1					
11.Exploitation Alliances	4,84	7,65	0,18	0,28*	0,22	0,24*	0,29**	0,24*	-0,06	0,34**	0,89**	0,70**	1				
12. Local Exploration	3,59	5,26	0,33**	0,08	0,06	0,00	0,21	-0,12	0,05	0,18	0,69**	0,87**	0,45**	1			
13. Local Exploitation	1,49	2,31	0,09	0,01	-0,03	0,12	0,09	-0,06	-0,11	0,09	0,70**	0,69**	0,72**	0,69**	1		
14. International KGI	0,39	0,49	0,33**	0,33**	0,09	0,07	0,21	0,04	0,24*	0,27*	0,26*	0,25*	0,18	0,15	0,06	1	
15. International Business	0,43	0,50	0,48**	0,27*	0,14	0,11	0,25*	0,25*	0,20	0,28*	0,37**	0,36**	0,32**	0,25*	0,18	0,61**	1

a *n(firms)=79;*

b Natural Logarithm;

Two-tailed tests.

Three approaches were employed to examine the hypotheses. First, a logistic regression model was used to determine main effects on technological performance. For the dichotomous form of the dependent variable (which measure whether or not firm has patent) a logistic regression analysis is suitable to estimate the effects of the independent variables. Second, scientific performance as a count variable was predicted by linear regression model. Third, in order to assess influences on economic growth, linear regression analyses were performed. The parameters are estimated using abovementioned procedures of the SPSS 20 statistical package. Table 2 presents the logistic regression estimates for the base model and main effects.

Table 2:
Results of logistic regression analysis predicting technological performance

	Base Model	Model 1	Model 2	Model 3	Model 4
Variables	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**	**Coefficient**
Control variables					
Cluster	1,39 *	1,32 *	1,58 *	1,53 *	1,43 *
	(5,13)	(4,38)	(5,23)	(5,06)	(4,17)
Size	0,28	0,23	0,16	-0,21	-0,20
	(0,65)	(0,42)	(0,20)	(0,28)	(0,21)
Part of MNC	0,26	0,30	0,42	0,68	0,21
	(0,07)	(0,10)	(0,19)	(0,44)	(0,03)
Previous Patents	2,02 **	2,07 **	2,06 **	2,42 **	2,23 *
	(6,78)	(7,02)	(6,53)	(7,64)	(5,64)
Previous Publications	1,61 *	1,54 *	1,67 *	1,83 *	1,41 *
	(5,29)	(4,68)	(4,94)	(5,41)	(3,79)
Main effect variables					
Number of Alliances		0,01			
		(0,27)			
Exploration Alliances			0,16 *		
			(3,93)		
Exploitation Alliances			-0,14		
			(2,74)		
Local Exploration Alliances				0,37 **	0,36 *
				(7,32)	(5,40)
Local Exploitation Alliances				-0,43	-0,39
				(2,95)	(2,40)
International KGI Partner					-0,31
					(0,13)
International Business Partner					1,82 *
					(4,80)
Model					
Number of observations	79,00	79,00	79,00	79,00	79,00
Nagelkerke R Square	0,42	0,42	0,48	0,55	0,61
Likelihood Ratio Chi Square	29,25 ***	29,52 ***	34,31 ***	40,91 ***	46,90 ***
Random Model Classification Rate	62%	62%	62%	62%	62%
Overall Classification Rate	73%	76%	79%	82%	85%

*Significance levels * p < 0.05; ** p < 0.01; ***p < 0.001; Two-tailed tests. Wald statistics are in parentheses.*

The first column reports the base model including all the control variables. The coefficients for the cluster dummy were significant ($p < .05$) in all cases. More specifically, the positive signs indicate that firms located in these clusters (Catalonia and Madrid Biocluster) were more likely to have patents than the firms from other three Spanish clusters from our analysis. Therefore we need to note here that it would be interesting to study other context variables in order to conclude why cluster presence lead to more technological performance of the biotech firms from these regions. Another control variable that was found relevant in our study is previous patent activity which is significant (mostly $p < .01$) in all models and always with positive sign suggesting that firms which have developed patents previously have acquired technical knowledge to enhance further innovation. The positive and significant coefficient ($p < .05$) for the number of publications in previous period reflects that firm's scientific productivity positively affects the technological performance of firms in the industry. This finding holds true in the remaining models as well and proposes that the development of science may be closely linked to technology and propensity to patenting.

The second column in Table 2 shows results with the total number of alliances introduced into the analysis which is testing part of first hypothetical model. Since the coefficient is not statistically significant size of alliance portfolio does not have influence on technological performance of focal firm.

In model 2 we distinguished between the number of alliances with knowledge generating institutes considered as the exploration-based and alliances with customers and suppliers considered as the exploitation-based. It can be seen from the third column that exploration-based alliances have significant and positive coefficient ($p < .05$) suggesting that portfolios with exploration-based alliances are more prone to patent their discoveries. Biotech firm which has greater number of alliances with knowledge generating institutes is more likely to innovate (measured through patenting). However this finding could lead to conclusion that firms then should keep only exploration alliance to achieve greater technological performance and innovation. To avoid misunderstandings we examine separately the model with the percentage of exploration alliances in firm’s alliance portfolio (reported in appendix 2) where we found curvilinear relationship between exploration-based alliances and patenting activity.

Thus our results suggest that above some levels the exploration-based alliances start to diminish innovation performance.

The fourth column represents model 3 in which we tested influence of local exploration-based and local exploitation-based alliances on technological innovation. The positive significant sign ($p < .01$) of local exploration alliances indicates that maintaining formal ties with local knowledge generating institutes will enhance technological performance of focal firm. International orientation of partners was included next in to analysis distinguishing between the presence of knowledge generating institutes and business partners in alliances portfolio. The fifth column represents model 4 in which we are testing whether local or international alliances' partners matter for patenting innovations. Results show that both, local knowledge generating institutes ($p < .05$) and international business partners ($p < .05$) in alliance portfolio have positive influence on technological performance of focal firm.

Looking at the overall fit of each of the models indicated by their Nagelkerke R Square and associated chi-squares; we observed that the introduction of different types of alliances in model 2 significantly improved the fit of the base model. Another significant improvement occurred in models 3 and 4, with the introduction of the variables for different type of local alliances as well as international and local alliances partners. The predictive ability of the model can be assessed by comparison of the estimated model's classification rate to the random classification rate. All five models perform better than a random proportional chance model. The classification accuracy for a random model is 62 percent. The percentage of correctly classified cases in the five models reported ranges from 73 to 85 percent, a rate clearly superior to the random model.

Within a next step, linear regressions analyses were performed to test hypothesis for the scientific performance. The same logic and all explanatory as well as control variables are used in the analysis which results are presented in Table 3. The base model with only control variables is showed in first column explaining 31% of the variation in performance ($p < .001$). Any other additionally added model doesn`t lead to an improvement in R^2 thus we can say that neither size nor configuration of firms' alliance portfolio helps to explain scientific performance. What is clearly observed from this analysis is the tight relationship between science and technology since in all models both variables, previous technological and scientific activity are positively significant (mostly p < .01). Previous patenting activity (β ≈ 11.44, p < .01) enhances scientific performance of focal firm. As expected greater the number of firm's previous publications (β ≈ 7.66, p < .01) greater scientific performance in observed period.

Table 3:

Results of linear regression analysis predicting scientific performance

	Base Model			**Model 1**			**Model 2**			**Model 3**			**Model 4**		
Variables	**β**		***t* stat.**	**β**		***t* stat.**	**β**		***t* stat.**	**β**		***t* stat.**	**β**		***t* stat.**
Constant	-5,34		-1,21	-5,50		-1,24	-5,22		-1,16	-5,37		-1,19	-6,22		-1,37
Control variables															
Cluster	1,87		0,55	1,48		0,43	1,68		0,48	1,83		0,52	1,39		0,40
Size	3,11		1,64	2,90		1,49	3,16		1,61	3,30		1,67	2,99		1,51
Part of MNC	-0,45		-0,08	-0,25		-0,04	-1,08		-0,17	-1,18		-0,19	-0,18		-0,03
Previous Patents	11,44	**	2,62	11,70	**	2,65	11,88	**	2,60	11,57	**	2,57	10,29	*	2,24
Previous Publications	7,66	**	2,84	7,22	**	2,56	7,66	**	2,67	7,87	**	2,83	6,95	*	2,45
Main effect variables															
Number of Alliances				0,07		0,55									
Exploration Alliances							-0,12		-0,43						
Exploitation Alliances							0,15		0,41						
Local Exploration										-0,19		-0,41	-0,22		-0,47
Local Exploitation										0,20		0,19	0,20		0,19
Int KGI Partner													5,54		1,24
Int Business Partner													0,09		0,02
Model															
R^2	0,31			0,31			0,31			0,31			0,33		
Adjusted R^2	0,26	***		0,25	***		0,24	***		0,24	***		0,25	***	
F statistic			6,47			5,39			4,54			4,53			3,81
$^\wedge R^2$				0,00			0,00			0,00			0,03		
Change in F						0,30			0,11			0,09			0,64

Significance levels * p < 0.05; ** p < 0.01; ***p < 0.001; Two-tailed tests.

Further on, economic growth was empirically tested by linear regressions analysis. The results are displayed in Table 4. The first column is a base model that only includes the same control variables as previous except the previous patents and scientific publications as we consider these two as explanatory variables in this model. The control variables explain 23% of the variation in performance ($p < .001$). We can observe that size of employees ($\beta = .32$, $p < .01$) and firms which are part of multinational company ($\beta = .70$, $p < .05$) significantly affect economic performance. The next step of the analysis addresses the influence of overall size of alliance portfolio on economic performance over and above the base model including two previous dependent variables, scientific and technological performance. As can be seen in second column, it leads to an improvement in R^2 ($^\wedge R^2 = 0.14$, $p < 0.01$). Scientific productivity ($\beta = .01$, $p < .05$) as well as patenting ($\beta = .63$, $p < .01$) have both significantly positive influence on growth of the focal firm. However the coefficient of total number of alliances is not statistically significant what leads us to reject hypothesis 1 since we didn't find support for its influence on any of firm's performance.

Models two, three and four from Table 4 include gradually all other variables of interest as it was the case in previous analyses plus the dummy variable which represents if firm has patent as the proxy of technological performance and number of scientific publications in observed period. All of them are improving the base model (R^2 is improved significantly) but mainly because of the scientific and technologic variables. On one hand, we can observe that any alliance variable is not statistically significant proposing that alliance portfolio and its configuration doesn't have direct impact on firm's growth. On other hand, even if the main effects model in the last column makes a significant contribution over and above the base models ($^\wedge R^2 = 0.17$, $p < 0.01$) we can see that only no collaboration variables are making the difference. Technological performance ($\beta = .82$, $p < .001$) and scientific performance ($\beta = .01$, $p < .05$) have a positive influence on economic growth. In addition, firm's size maintains statistically significant positive effect on its growth.

Table 4:

Results of linear regression analysis predicting economic growth

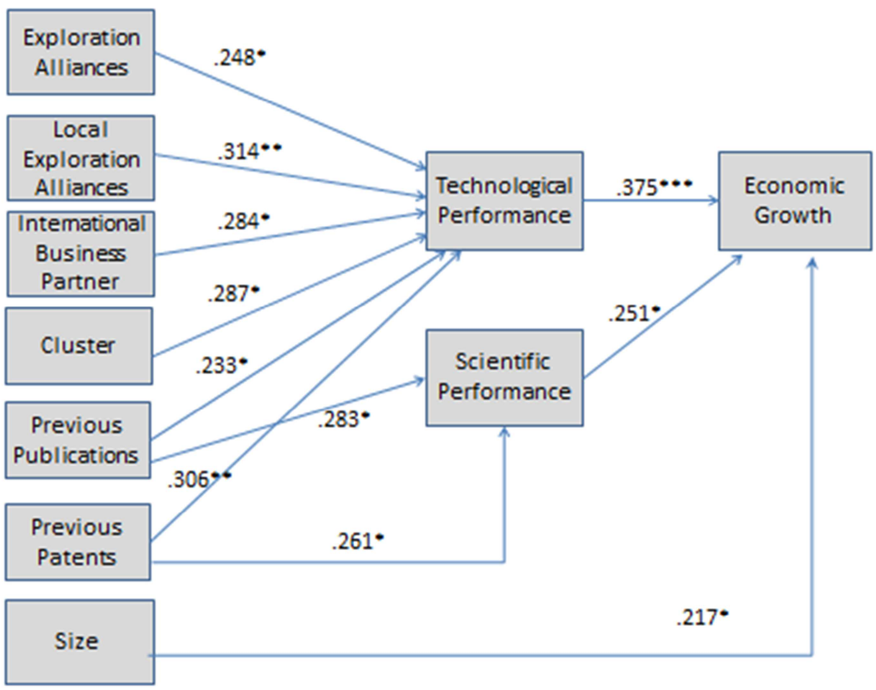
	Base Model			Model 1			Model 2			Model 3			Model 4		
Variables	**β**		***t* stat.**	**β**		***t* stat.**	**β**		***t* stat.**	**β**		***t* stat.**	**β**		***t* stat.**
Constant	-0,89	**	-3,27	-0,79	**	-3,12	-0,79	**	-3,12	-0,79	**	-3,08	-0,72	**	-2,79
Control variables															
Cluster	0,23		1,10	0,08		0,39	0,00		-0,02	0,06		0,29	0,05		0,26
Size	0,32	**	2,91	0,20		1,76	0,21	*	1,86	0,20		1,75	0,21	*	1,85
Part of MNC	0,70	*	1,99	0,59		1,80	0,43		1,29	0,51		1,50	0,57		1,62
Main effect variables															
Scientific Performance				0,01	*	2,02	0,01		1,61	0,01	*	1,89	0,01	*	2,16
Technological Performance				0,63	**	2,99	0,75	***	3,37	0,66	**	2,87	0,82	***	3,36
Number of Alliances				-0,01		-0,80							0,57		1,62
Exploration Alliances							-0,03		-1,76						
Exploitation Alliances							0,02		1,28						
Local Exploration										-0,01		-0,40	-0,01		-0,35
Local Exploitation										-0,02		-0,26	-0,01		-0,11
Int KGI Partner													-0,14		-0,54
Int Business Partner													-0,32		-1,20
Model															
R^2	0,23			0,38			0,40			0,38			0,41		
Adjusted R^2	0,20	***		0,32	***		0,34	***		0,31	***		0,33	***	
F statistic			7,62			7,20			6,64			6,11			5,25
$\wedge R^2$				0,14	**		0,16	**		0,14	**		0,17	**	
Change in *F*						5,43			4,77			4,05			3,35

Significance levels * p < 0.05; ** p < 0.01; ***p < 0.001; Two-tailed tests.

Within a final analysis, we calculated the partial correlation coefficients between the variables in line with the path analysis logic outlined by Blalock (1961; see also Davis, 1985). Figure 2 shows the obtained partial correlation coefficients whereby only significant relationships are illustrated because of the clarity. The obtained results are very similar to previous analyses we have performed in this study. It emerges the observation that economic growth seems to be path dependent phenomenon – as the positive relationship between certain portfolio configuration of R&D alliances and technological performance of focal firm. Besides that, scientific productivity in isolation contributes to the growth in direct way. Previous technological and scientific background is also very relevant for science and technology and their impact on economic growth.

Figure 2:

A Path model of alliance portfolio configuration influence on performance



To summarize, we have to reject hypothesis 1 as the alliance portfolio size didn't have any influence on three different types of performance examined in our research. As shown in Table 2, the results of the main effect models indicate that the exploration alliances (H2a) have a significantly positive influence on technological performance. H2b states that exploitation alliances positively affect firm's performance, but we didn't find evidence for this statement as it is not statistically significant in any of our models. Therefore, H2 is only partially supported. Both geographic proximity and international orientation of alliances' partners matter for technological performance. Nevertheless, local alliances with knowledge generating institutes (H3a) and presence of international business partner in alliance portfolio (H4b) are making differences. Thus, H3 and H4 are also partially supported.

5. DISCUSSION AND CONCLUSION

This study addresses the question of how alliances can improve performance and innovation in biotechnology firms. Rather than adopting a 'more-is-better' approach, which has dominated research on alliances and innovation to date, we opted for an assessment of the nature of the alliance portfolio and its impact on scientific and technological activity and economic growth. Even if we have tested influence of alliances on three types of firm's performance our results stressed that alliance portfolio and its appropriate configuration to efficiently exchange knowledge only may contribute to innovation and technological developments in biotech industry.

The results show that innovation performance is not driven by the mere size of firms' alliance portfolios. Rather, the organizational and geographic configuration of the portfolios influences technological performance, which in turn affects the growth of the firm. The impact of alliances on economic growth of the firm is hence indirect and only observed via performance in technology development.

Our study gives the relevance to the various sources of knowledge that the company can access. In addition to the search for new sources and types of knowledge, the direction and breadth of collaborations depends importantly on firms' research and development objectives. The greater innovation success occurs when firms search more broadly for knowledge in a variety of technological domains and geographic locations (Powell et al., 2005; Levitte et al., 2010; Ozer and Zhang, 2015). Our research goes in line with previous literature, remarking specifically the differences that the type of alliances and partners locations may have on innovation performance.

In terms of types of alliances and their organizational configuration, the findings show that the presence of knowledge generating institutes as alliance partners is positively related to the technological performance of the focal firm. Hence, exploration alliances – or alliances of a 'scientific' nature – are more effective and influential than exploitation-oriented alliances for biotech firms.

When evaluating the effect of the geographic composition of the alliance portfolio, we considered the effects of international and local alliance partners. As Gittelman (2007) stated, geographic proximity is important for technological innovation in biotech companies, but significant learning opportunities exist by reaching out beyond regional borders. Indeed, our results confirm that both international and local alliances positively influence technological development at the firm level. When taking a closer look at the type of local and international alliances' partners, the results reveal that benefits can be harvested mostly from local scientific partners, rather than from local customers and suppliers. Instead firms which have international business partner in its alliances will be able to develop technological innovations. In this way our study contributes to the literature giving the importance of understanding what effect on performance has each of these types.

From a managerial point of view, our study also has interesting implications. Local alliance connections in biotechnology are especially effective when they are with knowledge-generating institutes. At the same time, firms clearly benefit from connecting internationally, as the implied knowledge-exchanges, principally with business partners, allow them to keep up with new technologies developments. An alliance portfolio with a well-balanced configuration of local knowledge-resources and ties with international business partners entails potential for economic growth via technology development for the focal firm. Additionally firms which count with the quality scientific performance are experiencing economic benefits and are likely to progress even more as science and technology are tightly connected.

This paper has some limitations. First, our focus on Spanish biotech firms does not guarantee that the results obtained can be generalized to firms situated in other countries. Secondly, we focused on biotechnology, where field-specificities (e.g. in terms of the importance of science) underlie some of the uncovered results. Hence, similar studies in other countries and sectors will be revealing about the presence of potentially moderating effects of both national innovation systems and industry-related characteristics. We hope our study inspires to engage in such complementary research activities.

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CHAPTER IV

THE ROLE OF SCIENTIFIC ACTIVITIES FOR FIRM'S TECHNOLOGICAL INNOVATION

1. INTRODUCTION

According to the knowledge-based view of the firm, heterogeneous knowledge bases and capabilities constitute a key ingredient of value creation and innovation in firms (Grant 1996, Kogut and Zander 1992, Nonaka et al. 2000). The growing importance of knowledge as a productive factor and as a key element of the process of technological innovation can be explained by the continuous accumulation of scientific and technical knowledge over time, especially in knowledge-intensive industries. The understanding of the technological dynamism of economic activities is generally based on indicators of science and technology (Gittelman and Kogut, 2003; Van Looy et al., 2006; Van Looy et al., 2007; Callert et al., 2008). Effective management of scientific knowledge is fundamental base to ensure the generation of technological innovation and competitiveness. The existing knowledge base of the company is facilitating development of technology and innovation. To sustain competitive advantage firms must be able to continuously update their knowledge base (Zahra and George 2002). Thus firms must develop their own scientific capabilities. However, instead of developing capabilities exclusively in house, firms are increasingly relying on multiple external sources of knowledge which accumulate over time (Grant and Baden-Fuller 2004).

Motivated with results from our previous study where we found tight relationship between science and technology, we wanted to examine more in depth how firms' scientific activities influence technological development. Within this chapter we have distinguished between firms' scientific capabilities, scientific origin of firms and industry/science collaborations. Thus this study raises the question does firm benefit from combining strategies "make&buy" for the development of technological innovation. We will focus our research to local context as there is strong theoretical and empirical evidence that such formal (Lane and Lubatkin, 1998; Santoro and Gopalakrishnan, 2001; Furman and McGarvie, 2009) as well as informal (Pouder and St. John, 1996; Zucker and Darby, 1996; Zucker et al., 1998a; Feldman, 2000) linkages between local scientific institutes and industries are key channels for knowledge flows for biotech start-ups. Moreover previous literature has highlighted the relevance that the origin of start-ups as academic spin-offs which are also localized may have on performance (Feldman, 2001; Shane, 2002; Zucker et al., 2002; Colombo and Piva, 2008). In this sense we included in our analysis the origin of the firm in question (university spin off or independent NBF) and differences it may have on technological innovation.

Scientific capabilities of firms determine its existing knowledge base and represent source for innovation. Still, to improve their competitiveness companies cannot rely on the internal creation of new knowledge only. The benefits of combining internal creation with acquisition of new knowledge externally have been shown in previous literature. As a result of complementarity and absorptive capacity, firms enjoy greater returns when they pursue internal and external innovation activities simultaneously (Arora and Gambardella, 1990; Dyer and Singh, 1998; Cassiman and Veugelers, 2006; Hess and Rothaermel, 2011). This supposes that firms need to be able to combine newly created or acquired knowledge with the existing knowledge base of their components. The concept of 'combinative competencies' (Kogut and Zander 1992) sees the development of the ability to integrate and recombine new external and internal technological knowledge with the existing knowledge stock as a major challenge for companies to stay ahead of their key competitors.

Thus the aim of this research is to examine to what extant scientific capabilities ("make") of the firm will influence technological innovation. Moreover, we examine the moderation effect of two variables that may strengthen this relationship: firm's alliances with local scientific partners ("make&buy") and the scientific origin of the firm. Our results suggest on the one hand that while firm which have strong science base in-house will have more probability to develop technology, firms which collaborate with local scientific partnerships will be even more so. On the other hand, we did not found the evidence that genetic characteristics of university spin-offs make difference for innovativeness between biotechnology companies analysed in our study.

The chapter is organized as follows. First we present the theoretical background and develop the hypotheses. Then we describe the data and measures, followed by the statistical results. Last, the main conclusions, contributions and limitations are presented.

2. THEORETICAL BACKGROUND AND HYPOTHESES

2.1. Firms' scientific capabilities and technological innovation

The interplay between technological and scientific realms is increasingly considered as essential for being effective in terms of knowledge creation, technology development and its translation into economic activity. This phenomenon of 'scientification' of technology development seems to hold particularly true for new emerging, knowledge intensive fields of economic activity (Tijssen, 2001; Van Looy et al., 2007). The strengthening of the relationship between science and technological innovation has consequences for firms in high-technology industries. Particularly biotechnology firms increase their participation in basic scientific research activities by basing their promotion decisions for their scientists according to scientists' basic research activities and by employing star-scientists who publish extensively (Cockbum and Henderson, 1998). Gittelman and Kogut (2003) found that investing in scientific research may produce different results and relationship between firms' scientific capabilities and innovation because recruit and manage the intellectual capital is complex and challenging process. However firms that are able to perform a "good" science may attract the people necessary for innovation (Zucker et al., 1998; Cockburn et al., 2000). Therefore there are strong linkages between scientific knowledge capabilities and technological innovation of firms in knowledge-based industries (Cohen et al., 2002, Gittelman and Kogut, 2003).

Knowledge may be defined as the set of skills, experiences and know-hows that a person or group of them have in relation to a particular topic. When it comes to the knowledge possessed by an organization for its own purposes then is known as intellectual capital. For the purpose of this study and based on previous strategy scholars we consider that intellectual capital of company is reflecting its scientific capabilities. The perspective of intellectual capital conceptualized as the sum of all knowledge and knowing capabilities firms utilize for competitive advantage (Nahapiet and Ghoshal, 1998; Subramaniam and Youndt, 2005) and may have particular effect on innovation. Firm's innovative capacity is closely linked to its intellectual capital and knowledge held as well as the ability to make use of it, observing the innovation process as a process of intensive knowledge management. Considering the importance of scientific knowledge in developing technological innovation, it is necessary for the companies to implement methodologies that allow them to facilitate their management and incorporation of knowledge into new products and services. Knowledge management involves the management of all intangible assets that add value to the organization to get capabilities, or essential, distinctive competencies. Intellectual capital influences different types of innovation capabilities that a firm might have (Subramaniam and Youndt, 2005; Carmona-Lavado et al, 2010). Counting on quality scientists will enable firm to use their knowledge and if firm is able to manage this knowledge efficiently will develop its own scientific capabilities. Luo et al. (2009) found that scientist in biotechnology companies and their own networks in sharing information and results of their research are important for formation of alliances and in turn for development of scientific capabilities.

Firms "make" its scientific capability by conducting basic scientific research in-house which can increase its innovativeness for several reasons. First, science increases innovation by providing information that guides applied R&D towards trajectories that are more likely to generate successful outcomes (Nelson and Winter, 1982). More explicitly, basic research helps the firm to understand how and where to conduct more applied research, thus it is essential for decision making in product development or innovation strategies of the firm (Rosenberg, 1990). Second, science can help firms to create first mover advantages which are important for gaining competitive advantage (Lieberman and Montgomery, 1998). If findings from basic research can be translated into patentable assets, firms may gain first mover advantages and consolidate their position through patent protection (Rosenberg, 1990). Third, scientific research gives possible access to network which includes a variety of information flows from both basic and applied research categories. The community of science and technology are bridged by key scientists who engage in practices of both, including patenting, consulting, and joint publication among others (Murray, 2002). Fifth and the most relevant reason for our study is that an in-house scientific research capability is necessary to create absorptive capacity to understand outside scientific research. Regarding to Cohen and Levinthal (1990) in order to acquire, assimilate and utilize the external knowledge firms have to develop absorptive capacity. Developing scientific capabilities in-house will help firm to monitor and evaluate scientific research being conducted elsewhere (Cohen and Levinthal, 1990; Rosenberg, 1990).

Therefore, scientific capabilities determine the existing knowledge base of the firm and the qualification of their human resources which are also crucial for the creation of technological outcomes. Biotechnology is intimately tied to science and scientific knowledge that is why biotechnology process of R&D has multidisciplinary nature and wide breadth of knowledge is the most important for firms to take a step with innovativeness and to be successful. With continuous learning process firm can increase heterogeneity of its knowledge. The complexity of knowledge and its multidisciplinarity in knowledge-intensive industries is requiring wide range of relevant skills, information and expertise that firm must have at its disposal. Thus the importance for the firm to count with highly qualified human resources which may contribute to creating and exchanging of knowledge for innovation. Van Looy et al. (2006) found that firm's scientific research activity influence patenting activity suggesting that firms in knowledge-intensive industries have to be active in both basic and applied science. The positive relationships between scientific knowledge and technological innovation might stem from the presence of scientific capabilities (Van Looy et al, 2003, Van Looy et al, 2006). Scientific capabilities of knowledge-based industries are reflected in publications as a source of excellent coverage and quality for mainstream scientific production in the field of exact and natural sciences. From this perspective, the different issues of research related to biotechnologies are adequately represented in the scientific publications on the subject. Hence, further analysis is preferable (Van Looy et al., 2007) whereby scientific capabilities are taken into account in order to assess the relevance of using non patent references as an additional indicator to explain differences in technological performance.

In this line, we hypothesize that:

H1: Firms with higher scientific capabilities are more likely to develop technological innovation.

2.2. The moderating effect of science-industry collaborations on technological innovation

Whereas conducting scientific research in-house ("making") is important for the innovation, it is not enough; firms also have to be connected to the wider scientific community (Cockburn and Henderson, 1998; Oliver and Liebeskind, 1997; Owen-Smith and Powell, 2004; Pisano, 2010). Managing knowledge requirements through external sources may be conditionally better choice for young science-based firms because internal development often represents larger investments and takes longer time that firms have to respond on the market needs. Firms in technologically intensive fields rely on collaborative relationships to access, survey, and exploit emerging technological opportunities because the information is abundant and accumulates rapidly. As the structure of biotechnology becomes shaped by interorganizational relations, the direction of change is very much open. The capabilities of organizations are based in part on the qualities or capabilities of those with whom they are allied with and it is mainly influenced by their environment. If the firms interact broadly and engage in mutual learning with their local knowledge generating institutes they will be more likely to generate new knowledge and technology. In this way science-industry collaboration accelerates the rate of technological innovation.

Within the explorative strategy of biotechnology industry the environment is highly dynamic, thus opportunity cost of performing for a single company is higher in terms of inevitable access to new knowledge which resides elsewhere in the network. Besides, the drug discovery as a first stage is often dependent on discoveries made by university researchers. In view of the fact that about a third of the time and of the financial cost are at the basic science discovery stage, biotech firms are looking to share these high risks and costs with universities (Powell et al., 1996). Santoro and Gopalakrishnan (2001) stated that alliances with local universities allow firms to share the risks, to build on shared capabilities and to create synergies for better competitiveness. Previous research on the biotechnology industry has documented that the geographic collocation of firms is a function of access to scientific talent and the skills of "star" scientists who are active in both academic and commercial research communities (Zucker and Darby, 1996). Biotech firms collaborating with local universities will favourably affect their technology transfer activities because geographic proximity reduces the cost of face-to-face interaction (Santoro and Gopalakrishnan, 2001) which is highly recommended for exchange of tacit knowledge. Scientists are characteristically willing to exchange knowledge because of their intention to discovering new things in the perspective of their permanent laboratory work. At the extreme, when tacitness is high, the scientific researchers together with their team are who receive and transfer this knowledge (Zucker et al, 2002). As such, biotech firms are likely to leverage the expertise and know-how of university scientists in addition of building their own scientific capabilities. As much as young biotech firms need academic input to supply their early-stage R&D activities, they have to maintain a certain level of absorptive capacity to be able to fully benefit of scientific research (Arora and Gambardella, 1994).

The knowledge engaged in collaborations between university scientists and dedicated biotechnology firms is both huge (coming from a multitude of sources) and technologically specific. Thus company scientists will be able to assimilate external scientific knowledge ("buy") more effectively if they have previously performed similar research and acquired specific scientific knowledge themselves ("make"). Also, the ability of company scientists to comprehend and utilize external knowledge will be greater if they behave like members of scientific community. Simeth and Lhuillery (2015) studied capabilities of firms for publishing scientific results and their potential benefits. They argued that specific human resources allocation are required for achieving greater scientific capabilities which will enhance their knowledge codification skills and allow firm to benefit from complementary academic competences ("make&buy").

Recently, Soh and Subramanian (2014) studied university-industry R&D collaborations and effect of internal focus inside the firm (oriented to scientific research and/or technological recombination) on patenting performance. They found that for younger biotech firms only the scientific research focus enables them to benefit more from university collaborations. Young and small biotech firms which possess scientific capabilities and rely highly on university collaborations will be able to absorb new science and develop technologies (Soh and Subramanian, 2014). Moreover, Furman and MacGarvie (2009) suggested that collaborations with local universities had significantly contributed to the development of internal research capabilities of young firms and these interactions appear to have had a positive impact on the research outputs of early US pharmaceutical firms and on their rate of growth. Laursen et al. (2011) found that firms only benefit from collaborations with universities if they combine it with their own capabilities.

Hence, we propose that:

H2: Engaging in local scientific alliances will strength the positive effect of firms' scientific capabilities on technological innovation.

2.3. The moderating effect of scientific spin-offs on technological innovation

Previous research posited that initial founding conditions, available resources, strategic decisions at start-up of new businesses and their environments may have long-lasting effects on a firm's future development and growth (Barney, 1991; Delmar et al., 2003). Spin-off ventures are different from other start-ups, because they develop out of a non-commercial environment. Thus, during their formation these companies would acquire different organizational resources and capabilities from other start-ups which may foster scientific knowledge generation and innovation outcomes. Based on those difference Colombo and Piva (2008) highlighted 'genetic characteristic' of university spin-off firms may either increase or diminish the performance effects and eventually position them on growth paths that are different from those of other innovative start-ups. Previous literature supporting this argument have found on one side the success of academic scientists when engaging in business creation (Rothaermel and Thursby, 2005; Zucker et al., 2002) while on other side some studies showed that university spin-offs tend to stay small (Chiesa and Piccaluga, 2000; Zhang, 2009) and to grow less than other innovative start-ups (George et al., 2002). In general, the new venture performance is complex and multi-dimensional, still there appears to be empirical evidences which explain that academic spin-offs indeed perform different from other innovative firms in knowledge-intensive fields.

With respect to their performance in the first years after start-up, university spin-offs may clearly benefit from its links with the parent research organization. Regarding Rothaermel and Thursby (2005) university spin-offs may benefit from strong ties to their parent scientific research organization in terms of higher survival rates. Also, from the very beginning, university spin-offs may experience advantages from reduced personnel costs as in most cases the entrepreneurs are still employed at the university and may afford to offer their services to the new business below market prices. In this sense, the parent research organization may lower the new firms' initial financial needs and buffer the detrimental effect of funding (Colombo and Piva, 2008; George et al., 2002; Moray and Clarysse, 2005). Many knowledge generating institutes can develop the necessary expertise to support the needs of their spinoffs by offering expensive technical facilities and scientific equipment at subsidized costs or even direct financial support, such as loans that are free of interest for the first year. As part of their intellectual property policy, some parent research organizations may sustain the costs related to legal protection of the technological inventions their spin-off companies are based on. Hence university support enables academic spin-offs to invest a larger amount of their initial financial resources in processes fostering their growth and development than new ventures independently founded.

Moreover the university spin-offs are endowed with greater absorptive capacity which may allow them to enjoy significant advantages in exploiting their technological resources (Colombo et al., 2010). The scientific background of their founders and their connectedness to scientific community permit to spin-off firms to be more able to recognize the value of external knowledge, assimilate it and apply it to commercial ends (Cohen and Levinthal, 1990). Spinoff companies originating from universities translate new scientific knowledge into economic activity. In addition, regarding Colombo and Piva (2008) the marginal returns on investments in in-house R&D are likely to be higher for university spin-offs than for other innovative start-ups due to the technological specialization of their founders acquired in an academic environment.

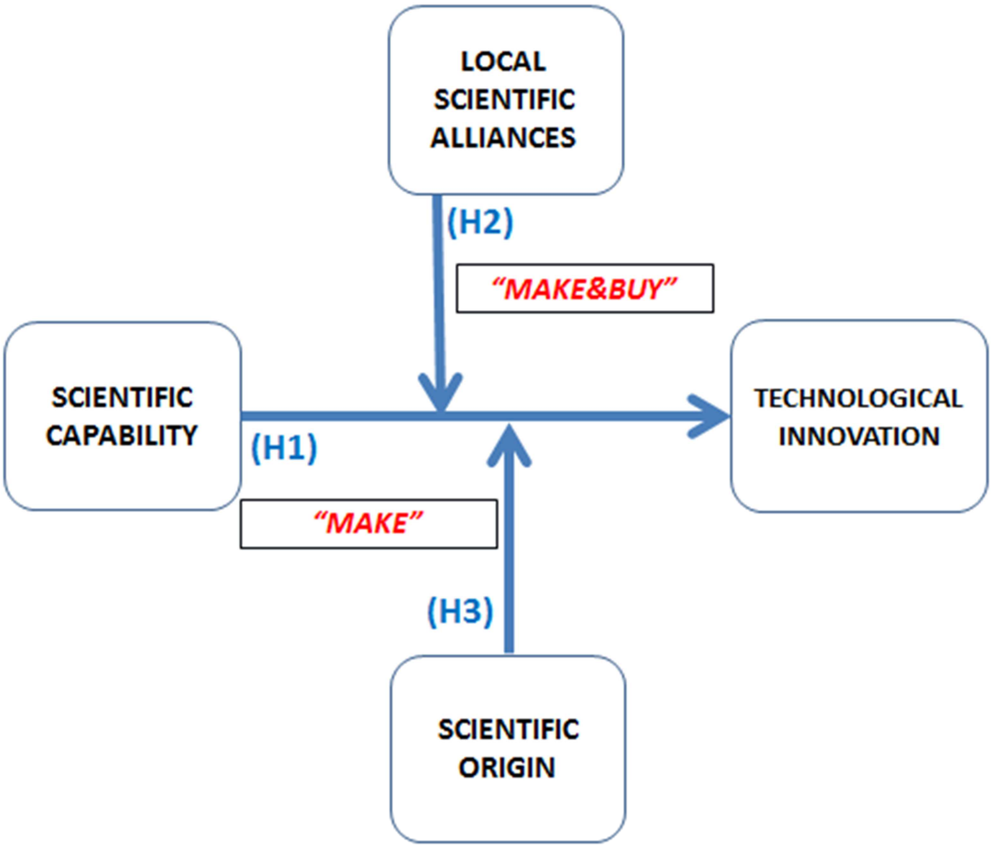
We therefore expect that the fact that firm originates from academic spin-off will positively moderate the relationship between scientific capabilities and technological innovation because of its greater availability to technological and financial resources of parent organizations (universities).

Thus our last hypothesis is formulated as follows:

H3: Scientific origins of firm will strength the positive effect of firms' scientific capabilities on technological innovation.

The following Figure 1 represents the posited hypotheses in our study.

Figure 1: Hypothetical model



3. DATA AND METHODOLOGY

3.1. Research Design and Sample

The empirical study has been focused on the Spanish biotech industry located in five most relevant regional clusters (Andalusia, Catalonia, Madrid, The Basque Country and Valencia). The mean of firm age in our sample is approximately 9 years, and about 60%

of them have less than 10 employees, thus our study is dealing with young and small firms. However it represents well the whole population since biotechnology industry in Spain is still relatively emerging sector and mostly comprised of small and medium enterprises. Only fully dedicated biotechnology companies have been considered for the purpose of our study and once the initial list of firms was filtered from the different sources the obtained population is comprised of 285 firms.

First data on firm's characteristics and alliances were collected conducting interviews with CEO and/or person responsible for R&D activities at the end of 2012 and beginning of 2013. During the interviews previously well-developed questionnaire was fulfilled allowing us to count on ninety three valid responses. Further on we consulted patent data of our respondent firms from EPO Worldwide Statistical Patent Database version October 2013 (PATSTAT October 2013 database). To approximate a firm's technological activities the information on firms' yearly patent applications in USPTO, EPO and JPO from 2000 to 2012 were collected. The data on company's scientific publications were extracted from the Web of Science database which provides access to the most relevant highly quality scientific results. At the final match we were able to find data on seventy nine companies representing the final sample response rate of 27.7%. To control and validate our survey we have compared the age and size of employees reported in questionnaires by respondents with age and size of employees available in SABI/AMADEUS data source which is a directory that provides financial and general data of Spanish and Portuguese firms. No significant differences were found, besides a non-response bias was not detected when we compared mean differences between respondents and non-respondents firms.

3.2. Measures

3.2.1. Dependent variable

The fact that firm has applied for patent from 2008 to 2012 in USPTO, EPO and/or JPO patent systems was used as a dependent variable in this study. The propensity to patent as proxy which reflects the high technological innovation is consistent with previous empirical researches about the nature and geography of innovation in biotechnology (Zucker et al., 1998; Niosi and Bas, 2001; Gertler and Levitte, 2005; Al-Laham et al., 2010). We opted to use binary variable, coded "1" if a firm has a patent and "0" if has not, to capture technological performance as firms from our sample, and generally Spanish firms, are barely patenting their activities, even less on international level.

3.2.2. Independent variables

Scientific capability was measured with the total number of scientific publications firm had recorded in Web of Science from 2000 to 2012 representing therefore firm's high quality scientific knowledge base. We consider for the purpose of this study that firms which were able to publish their scientific results internationally have developed specific capabilities to conduct well scientific research in-house.

Local scientific alliances were calculated for the previous five years as the total absolute number of firm's collaborations with knowledge generating institutes from the same regional cluster.

University spin-off is a dichotomous variable reflecting whether or not the firm was spun off from university. The variable is coded 1 if firm originates from the university and 0 if firm is founded as independent business.

3.2.3. Control variables

Cluster dummy: We controlled for possible differences in regions in which our sample companies are located (Andalusia, Catalonia, Madrid, The Basque Country and Valencia) in order to avoid the simple fact that just being present in certain region may lead firm to superior performance. We could control for all of them separately but to avoid bias due to the relatively small number of observations, we opted for the alternative to distinguish between two categories and introduced one dummy variable in the analysis. In terms of context Catalonia and Madrid are significantly more developed regions (with greater number of patents, scientific publications, researcher employees in DBF, etc.) thus the firms which are located in these two clusters are coded 1 and firms form other cluster are 0 coded.

Size: measured as the natural logarithm of firm's number of employees.

Previous technological activity: binary variable (0/1) if firm had patent before observed period.

Other alliances: we found relevant to control for the number of other alliances firm maintained with partners different from knowledge generating institutes within the same observed period. Those alliances may affect firm's ability to conduct simultaneously various collaborations or complement firm's research activities and thus may have also influence on performance.

4. RESULTS

The descriptive statistics are reported in Table 1 which details the means, standard deviations for the variables in our models as well as a correlation matrix. All of the variables used in the model have moderate inter-correlations ruling out a potential problem of multicollinearity among covariates.

Table 1: Means, standard deviations and correlation matrix

Variables	Mean	s. d.	1	2	3	4	5	6	7	8
1. Technological Performance	0,38	0,49	1							
2. Cluster Dummy	0,38	0,49	0,25*	1						
3. Size[b]	2,25	1,02	0,27*	-0,03	1					
4. Previous Patents	0,18	0,38	0,39**	0,05	0,20	1				
5.Other Alliances	4,84	7,65	0,18	0,24*	0,29**	-0,06	1			
6. University Spin Off	0,34	0,48	-0,12	-0,12	-0,07	0,02	0,04	1		
7. Local Scientific Alliances	3,59	5,26	0,33**	0,00	0,21	0,05	0,45**	0,16	1	
8. Scientific Capabilities	7,73	18,56	0,34**	0,07	0,42**	0,34**	0,32**	-0,14	0,09	1

a *n(firms)=79; b Natural Logarithm;*

Two-tailed tests.

Binary logistic regressions are used to analyse the hypotheses on the probability of involvement in patenting. Table 2 presents the results from this analysis including base model, main effects and potentially relevant interaction effects.

Table 2: Regressions

Variables	Base Model Coefficient		Model 1 Coefficient		Model 2 Coefficient		Model 3 Coefficient	
Control variables								
Cluster	1,15	*	1,30	*	1,30	*	1,18	
	(4,06)		(3,99)		(3,96)		(2,79)	
Size	0,48		0,02		0,02		0,21	
	(2,65)		(0,00)		(0,00)		(0,27)	
Previous Patents	2,13	**	2,20	**	2,22	**	1,76	
	(8,14)		(6,40)		(6,45)		(3,43)	
Other Alliances	0,03		-0,06		-0,06		-0,12	
	(0,56)		(1,28)		(1,30)		(2,18)	
Main effect variables								
Scientific Capabilities			0,10	*	0,10	*	-0,03	
			(4,09)		(3,93)		(0,12)	
Local Scientific Alliances			0,29	*	0,29	*	0,10	
			(5,25)		(5,38)		(0,38)	
University Spin Off			-0,88		-0,78		-1,01	
			(1,53)		(0,86)		(1,78)	
Interactions								
Local Scientific X SC							0,11	*
							(5,32)	
Spin Off X SC					-0,03			
					(0,06)			
Model								
Number of observations	79,00		79,00		79,00		79,00	
Nagelkerke R Square	0,32		0,51		0,51		0,60	
Likelihood Ratio Chi Square	21,38	***	36,82	***	36,88	***	45,77	***
Random Model Classification Rate	62%		62%		62%		62%	
Overall Classification Rate	75%		79%		79%		80%	

Significance levels * p < 0.05; ** p < 0.01; ***p < 0.001; Two-tailed tests. Wald statistics are in parentheses.

The first column shows the base model including all the control variables. The cluster dummy coefficient is significant (p < .05) with positive sing indicating more precisely that those firms located in reference category (clusters Catalonia and Madrid) have greater probability to patent than firms from other three Spanish clusters analysed in our study. Previous patent activity was also positively significant (p < .01) suggesting that firms which have developed patents previously will likely continue to innovate through patenting involvement. The finding related to these two control variables holds true in the remaining models as well.

In hypothesis 1, we proposed that firm's scientific capability would have a positive relation with patenting involvement. This is indeed confirmed in models 1 and 2 (column 2 and 3 respectively). The positive significant coefficient ($p < .05$) indicates that firms with higher scientific capabilities are more likely to develop technological innovation. At the same time column 2 and 3 also shows positive main effects of local scientific alliances ($p < .05$) on technological innovation (measured by patenting involvement).

As it can be seen in Model 3 the interaction effect between scientific capabilities and local scientific alliances seems to strengthen those positive relations on patenting, and that support our hypothesis 2. This result highlights that those firms which have strong scientific capabilities and are also engaged in local scientific alliances are even more likely to develop technological innovations measured through patents.

Finally, the data provide little support for the relevance of scientific origin of firm on patenting involvement. In any of models the variable university spin-off is not related to patenting. If we look in interaction effect from model 2 does not appear to be decisive that the fact that firms originate from university will strength the positive influence that scientific capabilities of firm have on technological innovation. As such, this result does not provide support for hypotheses 3.

5. DISCUSSION AND CONCLUSION

The focus of this research is to understand how firm while developing internal scientific capabilities may increase its technological innovation and how this relationship is enhanced by science/industry interactions (forming alliances with local scientific partners and being originated as academic spin-off). We recognized how firm's scientific capabilities and reliance on local scientific collaborations, as an important contextual variable, may influence a company's knowledge creation capabilities and account for variation in the firm's technological innovation.

Our results suggest that firm's scientific capabilities positively influence its technological innovation measured by patent involvement. The importance of scientific knowledge in knowledge intensive industry has been remarked in previous literature.

Van Looy et al. (2007) found that the technology is situated closer to scientific activity of firm. Similarly our study remarks that firms which are actually able to “make” science will benefit in terms of technological developments. Moreover, we underline the importance for firms to develop scientific capabilities in-house as this will improve their absorptive capacity. Firms with greater scientific capabilities are, therefore, more likely engaged in combining internal and external R&D activities.

Previous innovation strategy literature (Arora and Gambardella, 1994; Rosenberg and Nelson, 1994; Cassiman and Veugelers, 2006) has traditionally emphasized the complementarity arising from combining in-house and external R&D. Thus, firm's innovation performance is enhanced when it invests more in both, internal and external R&D. In this line, our results suggest that even if firm has developed its own scientific capabilities, the connectedness of the firm to the wider scientific community by forming alliances with local knowledge generating institutes may create additional benefits. Science-industry collaborations allow firms to employ better scientists and increase the creativity and motivation for research which will in turn result in better technological performance. Moreover, academic scientists will be more inclined to exchange ideas with people that they consider to be part of the same community. Through this firm can obtain traces about new trends, may learn about discoveries before publication, and get information that is not available in publications. Learning about discoveries prior to their publication is particularly important as it may lead to first-mover advantages.

Our study undermines the benefits arising from science-industry linkages. Owen-Smith and Powell (2004) give importance to knowledge generating institutes because of their abilities to increasingly conduct research which is both, advanced scientifically and immediately valuable to industry. It has been recognized that between external firms’ partners, collaboration with universities has been championed as a crucial component for innovation in knowledge-intensive sectors within regions as firms search for alliance networks and benefit from knowledge spill-over from their regional clusters (Owen-Smith and Powell, 2004). Generally, literature on clusters has implied that knowledge spill-overs and the easy availability of expertise inside of regional clusters benefits firms from just being present in the cluster. Informal processes of knowledge transfer do not suffice in technology-intensive industries such as biotechnology. Instead, as our study showed firms that realize more formal knowledge exchanges with knowledge generating institutes from their regional clusters perform better which underlines how small and medium biotech companies may overcome significant difficulties to stay in line with and access scientific knowledge for technological innovations.

Although there is large body of literature that gives importance to scientific spin-offs because of multiple benefits they count with in early stage of business development we didn't find those evidence in our data. Still we found this result very interesting for the discussion and further implications it may have. Suggesting that scientific origin of company doesn't make any difference in its performance make questionable the Spanish context and policies involved in academic entrepreneurship. Moreover this result is not so surprisingly in case of Spain as some previous studies have found similar results. March-Chorda et al. (2010) argued that Spanish university spin-offs are younger than the average company and less likely to have venture capital and patents. Besides, Pazos et al. (2012) found that Spanish academic entrepreneurs coming from a more bureaucratic environment tend to have less extensive managerial skills. Together with the findings from previous studies we consider that this opens the way to think of reformulating policies to help overcome localism and tightness that currently surrounds Spanish spin-offs. In the same time policy makers should make advances in the generation of knowledge exchanges and sharing resources between them all through promoting more effective forms of science-industry collaboration.

Our research also contributes to the literature. Cassiman and Veugelers (2006) studying complementarities in innovation strategies showed important empirical reveals on "make&buy" decisions (the concept previously introduced by Kogut and Zander, 1992). Following they call for additional research on this topic our results may contribute to the theory suggesting that complementarities of performing internal scientific research and external knowledge exchanges are favourable strategy for innovative firms. Thus the most relevant finding of our study is that firms will benefit even more of valuable knowledge exchanges with their local scientific partners if they count on their own scientific capabilities. While "make" only or "buy" only decision may result in positive technological performance, "make&buy" is even more favourable though.

We sincerely hope that our study revealing how complementarities in firms' innovation strategies may foster the technological developments and growth will have implications on further development of Spanish biotechnology sector. Again we highlight the tight relationships between science and technology and possible benefits of science-industry collaborations for innovation. Finally, we strongly believe that policy makers will take it into account those findings to foster such collaborations and improve the technological developments of their regions.

Certain limitations of this research should be taken into account when interpreting our findings. Peculiarities of biotechnology industry and it's highly dependence on basic scientific research may influence the studied relationships. Relying only on Spanish sample of companies could difficult the generalization of our results. However we believe that similar findings may be found in other countries where biotechnology is still an emergent sector. Thus we encourage research in different contexts to improve the predictive power and confirm the robustness of these results.

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CHAPTER V

HOW CLUSTER FACILITATES KNOWLEDGE EXCHANGES FOR INNOVATION IN BIOTECH INDUSTRY

1. INTRODUCTION

Throughout the years the linear models in economics have been gradually replaced by 'systemic'/ interactive models that give prominence to networks, and interaction relationships between social and economic agents. A similar evolution has occurred in the context of innovation. Over the last decades, science-industry relationships have received considerable attention, resulting from an increased recognition of the fundamental role of knowledge and innovation in fostering economic growth, technological performance and international competitiveness (e.g. Freeman, 1994; Lundvall, 1992; Nelson, 1993; Nelson and Rosenberg, 1993; Mowery and Nelson, 1999; Dosi et al., 2006).Until recently technological progress was explained from the linear model of innovation but nowadays other more robust theoretical frameworks were proposed, emphasizing the interactive model of innovation, as can be witnessed in the concept of national (NIS) or regional (RIS) 'innovation system' (Lundvall, 1992; Nelson 1993; Braczyk et al, 1998; OECD 1999) and the 'Triple Helix' model (Leydesdorff and Etzkowitz, 1996; Etzkowitz and Leydesdorff, 1998; Numprasertchai and Igel, 2005). As its own name indicates the ability of all actors to influence others and to directly or indirectly promote technological innovation is contemplated in the interactive model of innovation.

Both approaches combine the activities of three main actors: the industry, the university and the administration. In general, studies based on NIS and RIS suggest that public and academic efforts can "support, but may not substitute for the technological efforts of firms" (Nelson and Rosenberg 1993: 20). In order to foster absorptive capacity the development of human capital via education and training is essential. In the same time economic policies must be designed to compel international competitiveness. However, there are country/region specific issues for applying this perspective and thus there is a significant amount of variation among them.

In the Triple Helix model relatively more attention is paid to the role of universities. Traditionally, each of the actors involved acted in an independent way to perform his duties for innovation, consciously or unconsciously, but it has been in recent decades when it has confirmed the need to join efforts to multiply the value of these actions. Clear examples are the knowledge-based industries which are seeking technological innovations to optimize their processes and increase their competitiveness, and in the same time are giving a relevance to the implication of the university and other knowledge generating institutes recognized as ideal environment for research and invention stage. Although the relationship between the two seems obvious and binding, it has not been for a long time; even today is still required greater involvement to translate science into the market value and qualify the research to respond to customer demands. In short, it aims to bring scientific production to social consumption. As indicated by Etzkowitz and Leydersdorff (2000) it is the "Second Academic Revolution".

The interaction of groups of companies, research centres and government initiatives in regional areas can be a good instrument to improve competitiveness in knowledge-intensive industries. Especially in these industries those have tendency to cluster geographically. The idea of cluster concept appeared already in 1920 when Marshall pointed out that being present in industrial district enhance the innovative capacity of firms through localized knowledge spill-overs. Since then, clusters have been studied using several theoretical perspectives such as an institutional (Cooke et al., 1997; Lundvall, 1992), a strategy and competitiveness (Enright, 1998; Porter, 1990, 2000), and a knowledge and learning perspective (Bathelt et al., 2004), which are embedded in different research disciplines, among others, business studies, economic geography, and economics (Cruz and Teixeira, 2010). According to Cruz and Teixeira (2010) regional clusters have emerged as a vital context which may describe and explain different issues about competitiveness of firms, regional development, and the geography of innovation. Therefore the cluster literature provides some interesting arguments that this context may be extremely relevant for knowledge exchanges to take place between different actors because of different facilitators that such can provide to its participants. We may say that regional clusters implying triple-helix perspective and by trying to combine effectively three basic pillars of society can influence innovation performance and growth of the region. Nevertheless, not all clusters are equally effective in promoting the significant value of these actors' impact in knowledge transfer; thus further research is claimed (Chiaroni and Chiesa, 2006; zu Köcker and Rosted, 2010; Ingstrup, 2013) on enablers of innovation at cluster level_to explain the differences in competitiveness of clusters and regions.

In this line the following research question is posited:

How industrial, scientific and supporting driving forces enable technological development within cluster?

We focused on biotechnology sector as one of the most emerging knowledge-intensive industry to answer this research question. Although Spain has experienced growth in the last years in scientific production and the number of emerging NBF and other companies related to biotechnology it is still far away from the leading countries in the worldwide context in technological developments and innovation performance. Against this background, the aim of this chapter is to analyze the state of biotechnology in Spain more in depth in order to understand the evolution and structure of the sector as well as the nature / contribution of (regional) policies employed for the development of biotech clusters. Through the use of a multiple case study involving five different clusters we analyse the facilitators that may explain the differences in their performance and may help to clarify the way to improve the competitiveness and to reduce the gap with respect to the other European countries. As far as we are aware no previous study has been conducted to compare longitudinal data together with different stakeholders' opinions across Spanish biotech clusters. Our study provides interesting implications for policy makers and contributes to different streams of literature encompassing the facilitators that should be present within the cluster to foster technological innovation and competitiveness.

The paper is organized as follows. First, an overview of the literature on clusters, biotechnology industry and cluster facilitators as the theoretical background is provided. Next, the methodological techniques applied are described for creating and executing the multiple case study which continue with the presentation of cases. Hereafter, facts and figures comparing longitudinal data are presented allowing us to evaluate the success of studied cluster. Then, the case study findings are discussed. The main conclusions and policy implications are discussed in the final section.

2. THEORETICAL BACKGROUND

2.1. The relevance of the cluster

Literature in this field emphasizes in particular the role of regional clustering for ensuring the innovativeness, especially for young and small firms in knowledge intensive industries (Porter 2000, Cooke 2004, Ketels and Memedovic, 2008). One of the main reasons has to do with the fact that clusters favour the existence of a large stock of knowledge that will be available to its members. Porter (2000) defines clusters as “geographically proximate groups of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities”.

Knowledge management theory provides convincing arguments to explain how cluster can represent the context where knowledge is shared and exchanged, and new knowledge is created. Organizational knowledge creation can be viewed as a growing spiral process, starting at the individual level moving up to the collective (group) level, and then to the organizational level, sometimes reaching out to the interorganizational level (Nonaka, 1994). Spatial proximity offered by cluster seems to enhance the processes of knowledge creation activity and innovation. Nonaka (1991) emphasises that the sharing of tacit knowledge takes place through joint activities and requires physical proximity what can contribute to importance of developing the cluster knowledge creation capability. Cluster knowledge creation capability is the ability of group of organizations from the same geographical location to improve knowledge creation at organizational level.

Nevertheless, clusters can produce different results achieved from innovation process since not all of them are equally effective in the realization of knowledge exchanges. In fact, some research highlights that cluster membership does not necessarily determine the success or improve performance of companies. This idea has led researchers to analyse the conditions that must be present inside the cluster to effectively promote knowledge sharing and improve the innovative capacity of firms. Arikan (2009) has developed a theoretical model which describes which characteristics clusters need to have to provide knowledge creation capability that will lead to more knowledge exchanges among firms, enhance knowledge creation by individual firms and in turn improve innovativeness. In particular, firms located in the cluster will jointly become more innovative than the sum of individual firms because of synergistic effect produced from interfirm knowledge exchanges within the cluster. According to Arikan (2009) a cluster that has a high level of knowledge creation capability is one where knowledge is effectively shared among cluster firms and improved by individual firm's knowledge spirals, leading to increase knowledge creation and produce innovation outcomes.

In fact collaboration between industry, research, and public policy is a necessary precondition for the long-term growth of the cluster and need to be increased to ensure the creation of innovation. While the cluster provides access to a large stock of knowledge, this does not necessarily imply that knowledge sharing will take place. Therefore, it is imperative that within the cluster certain factors must be present to provide the exchange of knowledge and innovation as a learning process adopted by firms.

2.2. The complex nature of biotech industry

The biotech industry is a knowledge and R&D intensive industry, which is dominated by small and medium sized research companies. The development of products requires a very heterogeneous set of cognitive skills what is calling for a broad set of expertise, which can usually be found within a larger concentration of related activities. It leads to an increasing need for transdisciplinary network relationships (Powell and Brantley, 1992; Waxell, 2009). Thus, biotechnology is in its essence a result of cross-industrial and cross-disciplinary scientific synergies between a wide variety of actors across both public and private sectors. Even more biotechnology is characterized with technological uncertainty and long lead times. Thus continuous investments are crucial for new technological developments. The achievement of knowledge creation for innovation demands organizational coordination and efficient management of the actors and activities involved.

In this sense, the biotechnology sector has two features that should be highlighted. First, it is composed of a large number of small firms that have been created with the aim of commercializing research results. Second, these new biotechnology firms are embedded in a dense network of interorganizational relationships, primarily with universities and large pharmaceutical companies. Biotechnology is considered as a sector with an extensive reliance on external collaborations (Powell, 1996; Liebeskind et al., 1996). As biotechnology is intimately tied to science and scientific knowledge, the process of biotech R&D has multidisciplinary nature. Therefore biotechnology firms collaborate with universities, research centres, government agencies, firms which provide various services, pharmaceutical companies and others (Oliver and Liebeskind, 1997).

Moreover, biotech firms tend to cluster because local linkages provide closely coordination which may improve their innovativeness. In the literature biotechnology is considered largely clustered industry (Stuart and Sorenson, 2003). By fostering communication and cooperation dense local clustering provides information transmission capacity in the network. With clustering biotechnology firms seems to be benefit of having a broad set of actors with expertise from different positions in the value chain (Powell et al., 1996). It has been shown that in industries where knowledge is highly tacit, a clustered network structure facilitates the flow of knowledge (Cooke, 2001). Knowledge spill-overs, or externalities, are responsible for the geographical clustering of biotechnology firms. Innovative organizations generate knowledge, some of which 'leaks' towards other organizations. As much of this knowledge is tacit, a particularly in new activity such as biotechnology, geographical proximity is the key factor for an organization to absorb such externalities (Niosi and Bas, 2001).

Following St. John and Pouder (2006) biotechnology as one type of technology clusters may be viewed as driver of enhanced synergy and value creation. This suggests that the biotechnology cluster may be considered as a unique accumulation of different value-creating resources whose union creates synergy and provides advantage in the ability to create new firms and recombine industries applications available within the cluster. Biotechnology clusters have an opportunity to sustain competitive advantage across a set of existing and emergent industries rather than focusing on a single industry. The opportunities for recombination of biotechnology applications associated with its broad knowledge base and entrepreneurial alertness enable clusters with capabilities to have an opportunity to persist over time.

2.3. Biotech cluster facilitators for knowledge exchanges

In spite of the relevance that biotech cluster may have as a favourable context for knowledge exchanges for innovations and technological developments, the dynamics of clusters to growth strongly vary from case to case. Based on previous literature (Chiaroni and Chiesa, 2006; Arikan, 2009; Ingstrup, 2010; Sydow et al., 2011; Ingstrup and Damgaard, 2013) we propose that this difference may be given by certain facilitators existing within the cluster. In our research a set of facilitators grouped in three factors (industrial, scientific and supporting) are considered and examined.

Industrial driving forces

In regional clusters there is need to have a sufficient number of participants (*critical mass*) present in a cluster for interactions to have a meaningful impact on firms' performance. A larger number of similar and related firms in a spatial cluster provide more vibrant and valuable local buzz. According to Bathelt et al, (2004) the importance of existence of high quality local buzz is in the fact that the same one leads to a more dynamic cluster able to attract and retain a *critical mass*. The particularly successful clusters are the ones that are able to build and maintain a variety of channels for low-cost exchange of knowledge. This argument affirms that a vibrant cluster is centred upon relations between different actors that share a common knowledge and competence base inside the biotechnology cluster (Waxell, 2009). It is very important to understand how the cluster has evolved over time and the complementary nature of its critical mass; which actors or participants have been involved in knowledge spill-overs and how they are strategically sourced within the biotechnology cluster.

Most of the companies that belong to biotech clusters are SMEs, although it is true that some large established companies (*anchor tenant*) are also part of the same, acting in many cases as driving force for other smaller companies as they play key role in the development of the new technology (Carbonara, 2002). Waxell (2009) highlights importance of evolutionary understanding for how knowledge and competence structures are formed by anchor firms in local biotechnology clusters that are attracted to the cluster, and are contributing to enhance the visibility of organizations. The existence of *anchor tenant firms* may actively and strategically contribute to cluster growth by opening up action spaces and markets for complementarities while being able to adopt new technological opportunities (Lecocq and Van Looy, 2013). Actually, the presence of business leaders who act as driving force of the agreements and knowledge exchange within the cluster can be the result of the major attractive force that cluster has exercised at some given time, but that's not something that can be managed immediately. Collaboration between small biotechnology firms and large pharmaceutical firms in favour of achieving technological development is challenging to continuously search for more effective ties to compete on global market.

Scientific driving forces

Biotechnology industry demands both, knowledge and capital. Thus the main characteristic of the biotechnology is that it depend of public research oriented organizations and universities as well as investors willing to finance research or product development processes. Accordingly, the biotechnology cluster is made of more than just small biotechnology firms and large established firm. The potential benefits for knowledge exchanges and innovation may be driven as well by entrepreneurial-oriented scientific institutes. *Recognized research centres* represent source of highly qualitative scientific knowledge which is applied for the development of technological innovations. Waxell (2009) observes a biotechnology cluster as a coherent system of relations between actors that utilize a similar pool of knowledge and skills, specifically in biotechnology-related areas. Historically, research in universities and public research centres has had as main objective the generation of scientific knowledge, and the metric used to assess the quality of the research has been published in scientific journals of high impact. The concept of basic research has been changing towards translational research to industrial application and leading to products or transferable services from laboratory to society. In this sense, the notion of '*entrepreneurial universities*' (Branscomb et al., 1999; Etzkowitz, 2004) has increasingly been used in relation to the spectrum of evolutions faced in recent years by academia. This concept suggests more involvement in economic and social development, more intense commercialization of research results, patent and licensing activities, the institutionalization of spin off activities and managerial and attitudinal changes among academics with respect to collaborative projects with industry (Etzkowitz, 1998; Chiesa and Piccaluga, 2000, Van Looy et al., 2011). Scientific research is crucial for the biotechnology as greater number of *entrepreneurial universities* and others knowledge generating institutes that are science and technology intensive influence development of the industry. The basic and applied research skills needed to create new products are based in universities and *recognized research centres*. Also, the proximity to these knowledge centres will produce innovation advantages (Porter, 1998) reinforcing the industrial and the scientific base of the area as well as facilitate the collaboration between industry and science (Chiaroni and Chiesa, 2006).

Supporting driving forces

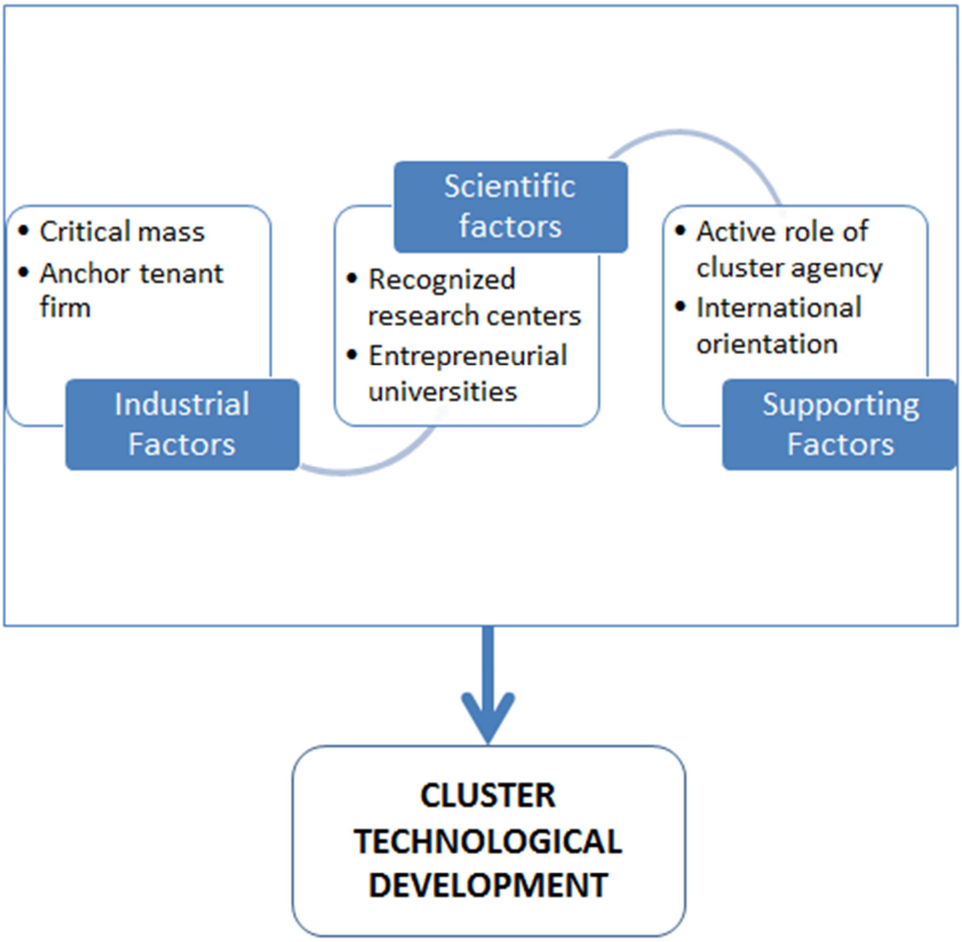
Biotech clusters are usually promoted by government with cluster-oriented policies (Enright, 2003 Dohse, 2007). Economic and regional policy supports cluster formation and development by establishing or promoting the necessary hard and soft infrastructures for cooperation. In many countries, policy also promotes the creation of cluster structures and the services of *cluster agencies* and its management of the businesses and other actors in clusters. In that way, this cluster agency as organization that manages the cluster is responsible for implementation of cluster regional policies (Okamuro et al, 2011). The *active role of cluster agency* is a crucial parameter which provides a platform to better leverage existing assets in the cluster's business environment (Huxham et al, 2000). As innovation benefits from the proximity of organizations, cluster management organization have an important role to play to support innovation by offering services and other mechanisms that augment the inter-linkages between all actors.

Success of cluster also depends of its ability to connect to global markets, thus the *international orientation* has to be actively promoted. As we have mentioned before biotechnology firms call for partnerships of all kinds. The chance in an emerging industry is that currently there are enough critical groups all over and a concentration of expertise to supply this definitely may not be found in one place. The collaboration on international scale is required because of particular relevance that the introduction of new knowledge and skills has for technological development of a region (Cooke, 2001;

Lecocq and Van Looy, 2009). The biotechnology firms are then forced to look outside their locality and cluster organization may provide the good platform for global networking while maintaining cooperation with other cluster project or worldwide associations. Boosting interregional and *international orientation* makes cluster as an environment that provides open access to knowledge, strengths ties between academia and industry, and promotes a culture of protection of results and cooperation between regions; facilitates entrepreneurship, the enhancement and incubation of projects, promotes the exchange of best practices, to attract talent, funds and opportunities, and exploits the advantages of networking (creation and strengthening of networks) for the benefit of local development.

The following Figure 1 summarizes the factors and facilitators proposed for the analysis in our case study.

Figure 1: Cluster facilitators and factors for the success of cluster



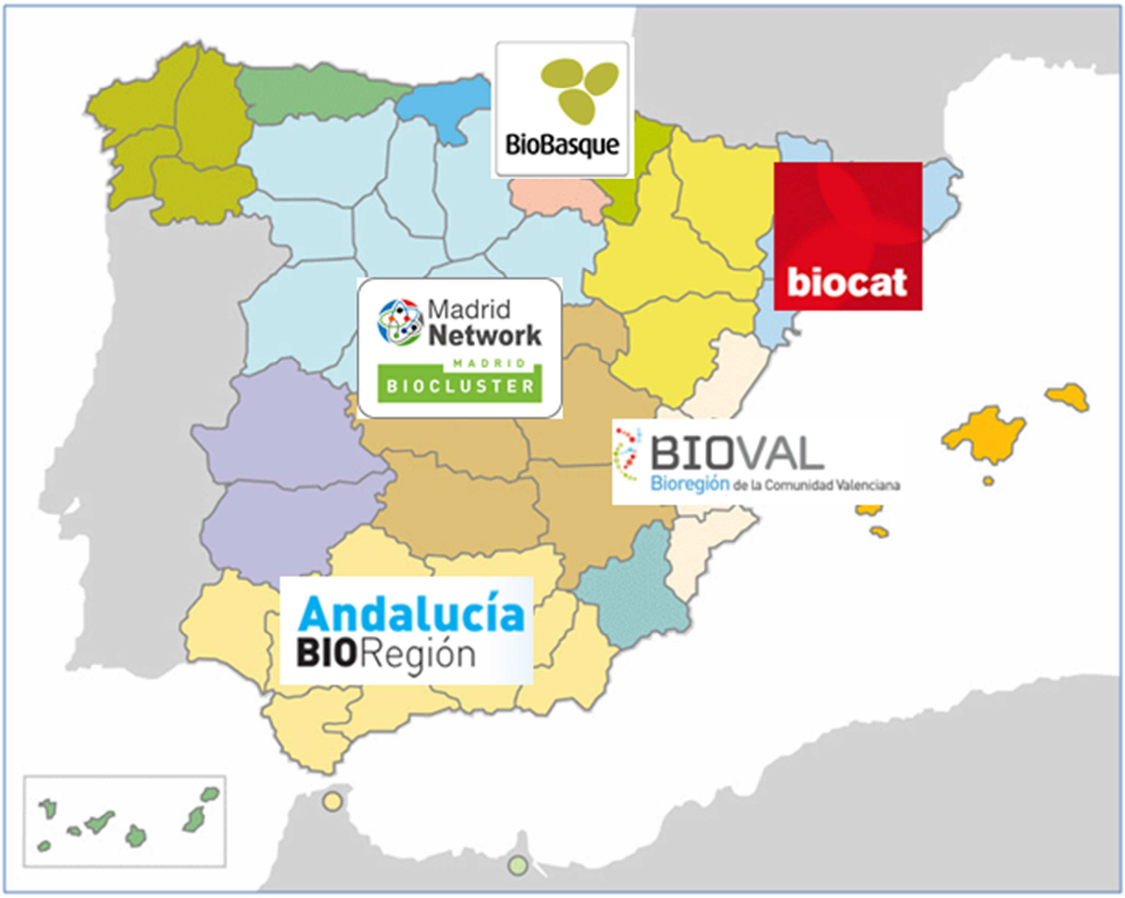
3. THE COMPARATIVE CASE STUDY OF SPANISH BIOTECH CLUSTERS

A multiple case study has been conducted in order to advance the literature and research about the factors that have to be present within the cluster to improve its competitiveness. In this sense we identified to what extent the context enables different trends of technological development and which are the cluster facilitators of knowledge exchanges for the evolution of biotech clusters. In our research the success of cluster is determined by the number of biotechnology patents. Multiple case study as the research strategy are effective because they enable collection of comparative data and so are likely used in the quest for both analytical depth and comparability (Yin, 1994). Moreover, Acs and Vargas (2002) claimed that case studies are being preferable and suitable approach for examining clusters and cluster-based phenomena.

The setting for our study was the Spanish biotechnology industry and the implemented cluster policies, which was appropriate for several reasons. First, the Spanish biotechnology sector has been growing over the last decades. Though this focus is relatively new in Spain, the strong scientific environment has provided a rich medium for the rapid growth of biotechnology, which has seen intensive investment and development in the past years. National and local governments have increased funding for research, created new research centres, and provided mechanisms to advance technology transfer. Without doubt, biotechnology has experienced exponential growth in recent years, and is expected to continue in the future to be one of the key sectors for economic growth as recently stated in its annual report the Business Council for Competitiveness (CEC). The same report states that Spain occupied the 4th place in Europe and 10th worldwide in scientific production by the end of 2011, and places the biotechnology sector between 6 key sectors for economic competitiveness of Spain. However in international comparison of technological achievements Spain is still far from other countries like the US or other EU countries as reference. Second, after the founding of the Spanish Association of Biotechnology Companies (ASEBIO) in 1999, there have been various business associations, on both national and regional level. Five biotechnology clusters have been created in Spain recently as shown in Figure 2. Grouped in the Spanish BioRegions Network (RBR) which was created in 2008 these are: BioBasque (The Basque Country), BioCat (BioRegion of Catalonia), BioVal

(Valencia), Madrid Biocluster and Andalusia BioRegion. The purpose of creation of this network is to represent a turning point in the sector and respond to the need to create an instrument that brings together the Spanish bioclusters facilitating the coordination of initiatives and interlocutor between regional and central government concerning the development of the biotechnology sector and biosciences. Other regions are also in the process of organizing their own bioclusters Canarias, Extremadura, Aragón, Navarra and Balearic Islands; which were expected to join this association in the future.

Figure 2: Map of Spanish biotech clusters



The sample of our study is composed of these five clusters showed in Figure 2 which represent the vast majority of biotechnological activity in Spain, whether technological, industrial or commercial (Genoma España Report (2011)). However, those biotech clusters in Spain vary widely in structure, evolution and goals and hence each cluster represents a local complex system where different types of organizations interact for research, knowledge creation, technological developments and prosperity. Performances of these clusters also differ from each other so there is a need for their deeper investigation to understand the facilitators of knowledge exchanges for innovation.

The data used for the multiple case study stem from several data sources: 1) extensive archives, including business publications, Internet sources, corporate materials and annual reports; 2) other documents and literature studies; 3) secondary available databases for science, technology and economic data (WoS[4], Patstat[5], INE[6]); 4) interviews with different groups of stakeholders (15 actors from the five clusters and 2 experts in the topic). Quantitative data have been complemented with interviews with (local) experts; these interviews have been conducted in a semi-structured way and aimed to better understand the observed 'growth' patterns and their antecedents. We started with the pilot interview with an expert in the topic, the ex-president of Genoma España, a government-funded organization that promotes biotechnology research and practical applications. Then we interviewed policy makers (representative of the cluster agency) from each of the five clusters. Moreover, from every cluster we have selected two companies to interview depending on the trend of technological development in terms of biotechnology patents that have generated in the EPO (European Patent Office) in recent years (the period 1990-2010). The logic we have followed for selection was: one company which has been actively involved in patent generation over the years and another company which is not pursuing this strategy and does not have continuity or doesn't have patents at all in its technological portfolio. The aimed informants were those involved in research activity, development and technological innovation, typically CEO, CSO (Chief Science Officer) or R&D managers. Finally we conducted interview with IPR (intellectual property rights) manager of CSIC[7] (Consejo Superior de Investigaciones Científicas) who acts as a head of technology transfer at the protection of results and creation of technology-based companies unit in Seville.

The interviews served to shed light on to what extent the context and its facilitators explain different trajectory of technological development and evolution of biotech clusters in order to identify the success factors. The interviews were conducted between the month of April and September of 2015 and lasted between 30 minutes and one hour.

[4] An online scientific database by Thomson Reuters
[5] EPO Worldwide Patent Statistical Database
[6] Spanish National Statistics Institute
[7] CSIS is the most relevant public institution for scientific research in Spain.

All interviews have been recorded via *Skype Recorder* with the intention of posterior transcription. Although we used open approach aiming to obtain explanations of different stakeholders on cluster evolutions and success factors in order to compare the data and align the interviews we used a guide with some sub-questions. We asked the informants to describe the regional potential of their clusters, if the fact that the firm is located in that specific context provides benefits for innovation, if there are any anchor tenant companies and what role do they play for technological development throughout the cluster and to what extent the formal biotech cluster agency is fostering different facilitators for innovation to take place. Additionally policy makers were asked about the origins, structure and characteristics of the cluster and policies they are responsible for. Table 1 gives the overview of interviewed companies conducted at each cluster in the sample and the titles of informants; the table also indicates the patents data of each firm we interviewed.

Table 1: Overview of the interviews

Name of the Company	Title of Focal Informant	Web page	Biotech Cluster	Number of EPO Patents	First Patent (year)
Newbiotechnic	CEO	http://nbt.es	Andalusia	8	2000
Pevesa Biotech	R&D Manager	www.pevesa.com	Andalusia	1	2001
Esteve	R&D and Operations Director	www.esteve.com	Catalonia	13	1992
Omnia Molecular	CSO (Founder)	www.omniamol.com	Catalonia	0	
Leti Laboratorios	R&D Director	www.leti.com/en	Madrid	12	1990
Secugen	Managing Director	www.secugen.es/en	Madrid	0	
OWL	General Manager	www.owlmetabolomics.com	The Basque Country	8	2004
Dynakin	R&D Manager (Cofounder)	www.dynakin.com	The Basque Country	0	
Biopolis	CEO/CSO	www.biopolis.es	Valencia	1[8]	2010
Biotica	R&D Manager	www.biotica.es/en	Valencia	1	2008

Next we describe the historical background, policies characteristic and the current status of the selected clusters as well as the main activities performed by the respective cluster agencies in these clusters. The general overview of the five studied clusters presenting the cases is followed by the Table 2 which summarizes the relevant information about the clusters and their policies for our study.

[8] There are only 13 patent applications in EPO from Valencian business sector and those belonging to 11 companies. In this case we have checked further sources and used indicators from other patent offices to identify more successful firm in patent generation.

3.1. The general overview of the five clusters

Andalucia BioRegion (Andalusia)

Andalucia BioRegion is the strategic booster unit of the Andalusia Biotech Cluster which depends 100% of IDEA[9], the regional government agency of innovation and development of Andalusia. The Andalucia BioRegion is based at the health sciences technology park in Granada.

Since 2003 Andalusia has occupied the second or third position with regard to the number of firms with exclusively biotechnology activities, compared to other Spanish clusters. In 2012 it has reached the maximum of 99 DBF existing in the cluster and the biotechnology industry has created over 2.500 jobs in public and private sector (INE). Most of the firms belonging to the cluster are SMEs. Andalucia BioRegion has 10 public universities but only 2 of them are very active in biotechnology. The main biotechnology activities performed in cluster looks like this:

- 35% of activities correspond to Bio-Agri,
- 31% to Bio-Pharma,
- 17% to Bio-Industrial,
- 10% to Bio-Informatics and
- 7% to other services.

The classification is a little bit different from other cluster and the principal difference resides in the high proportion of bio-agriculture activities. It is obvious that more activities in this case are related to green biotechnology since Andalusia is traditional agricultural region.

The mission of the Andalusia Bioregion is to link together firms, research teams, hospital and bioregions through strengthening the knowledge generation stages and its transfer to the industry. The main objectives are to develop the industrial sector and promote research and transfer of knowledge in the sector to become globally competitive and to win the size and quality of job creation. There is no formal strategic

[9] Agencia de Innovación y Desarrollo de Andalucia

plan. Mostly the funds of agency have been allocated to the activities and initiatives such as participation in fairs, actions to awareness-raising and revitalization of projects, representing expansion project or R&D performing by companies.

BioCat (Catalonia)

The BioRegion of Catalonia is a biotechnology, biomedicine and medical technology emerging cluster concentrated around the University of Barcelona Scientific Park and the Pompeu Fabra University. It has become one of the main biotechnology cores in Spain with the highest level of patents in the application process and accounts for 35% of the Spanish R&D investments in biotechnology firms. This cluster is also starting to be competitive between other European bioregions with its high ranking of entrepreneurs/start-up firms.

In this cluster there is a large presence of important international pharmaceutical companies. However, most of the biotechnology firms within the cluster are SMEs (60% of all biotech firms have less than 10 employees). There are more than 350 companies (around 110 are exclusively dedicated to biotechnology), 70 of them belongs to pharmaceutical sector, 150 to medical technology, 27 to fine chemicals, and the rest provide support and other services. It created more than 6.550 jobs in biotechnology sector in 2012 (INE). The cluster also possesses a strong and wide network of research centres and science parks (9 of them are exclusively devoted to life science), 11 universities, 13 hospitals and other supporting structures. The Barcelona Science Park (PCB), established by the University of Barcelona in 1997, was the first science park in Spain. The European Observatory for Biotechnology is located at the Barcelona Science Park.

Red biotechnology remains the main activity of the cluster (64% of companies focus on Bio-Pharma) and work on drug discovery and development. Catalonia includes 52,7% of clinical trials which represents the highest number than any other region in Spain. The distribution of other biotech firms' activities is: 15% of activities are related to Bio-Agri, 12% to Bio-Industrial and 6% to others services.

The cluster is driven by a cluster organization called BioCat that coordinates all activities from research to market, fostered by various governmental funds and political support. Biocat promotes, stimulates and coordinates actions to promote biotechnology and biomedicine as an economic engine. Mission of BioCat is to help creation of the right environment adding value to bioscience in region with an active, efficient and dynamic knowledge-transfer system. Biocat structures its activities around five major strategic areas: cluster consolidation, business competitiveness, internationalization, training and talent and social perception of biotechnology. Cluster's consolidation as a network of knowledge and collaboration is considered essential to achieving goals related to both scientific and business growth and improvement. Featuring the high quality of research institutions and successful organization of international networks, this cluster attracts more and more scientific talents.

<u>Madrid Biocluster (The Community of Madrid)</u>

Madrid Biocluster is created to support the common interests of its members and promote the development of biotechnology in the Madrid region. Since biotechnology is considered as a high technology activity which requires mostly a short distance for tacit knowledge exchange, sustained physical presence and face to face relationships with the universities, hospitals, and governmental entities, Madrid region is very well suited for the development of sector.

This cluster gathers 400 companies related directly or indirectly to biotechnology with around 6.400 employees in 2012 (INE). These are pharmaceutical, biotechnology and medical device companies, PROs and academic research centres. Until 2013 in Madrid region there were 93 fully dedicated biotechnology firms, mostly SMEs but only 42 are formally belonging to the cluster. These DBF assign a great amount of resources to R&D activities in various life sciences areas such as clinical genetics, bioinformatics, agrobiotechnology, cancer research and others. Madrid Biocluster includes 6 universities and more than 20 academic research centres, plus 7 scientific (research) parks which are in operation. It is also characterized with the highest R&D investment (83%) by biotechnology private firms in Spain and almost 3.000 biotech researchers working in public research centres and universities.

Madrid Biocluster has five major areas of activities for its participants: business cooperation, internationalization, training and talent-attracting, financing of projects and everything related to infrastructure, since biotechnology companies tend to settle in common platforms to foster synergies and complementarities. The principal objective sought is to become an international cluster, supported by the potential in the region, embodied in researchers, public institutions and business development initiatives. Moreover, the cluster agency mostly aims to help increase the supply of funds for R&D and thus the majority of the efforts and agency budgets are dedicated to the presentation in international projects which will provide the required funding for the research projects of its participants.

BioBasque (The Basque Country)

BioBasque is small but vibrant biotech cluster from the Basque Country. It represents the pioneer cluster policy in Spain and its strategic mission is to establish an international competitiveness. The BioBasque agency belongs to the SPRI[10] (Basque Development Agency) a public company dependent on the Basque Government.

The business sector, in the BioBasque, includes about 70 actors, from which almost 50 are fully dedicated biotechnology firms which benefit from leveraging different expertise and meeting technologies. It possesses more than 20 research institutes and universities including 6 leading hospitals (4 of them are university hospitals). The total number of employees in biotechnology sector has been growing continuously and in 2012 (INE) it reached more than 1.260 employees in both the public and the private sector. Origins of start-ups are divided on the next way: 41% university and research centres, 31% private sector and entrepreneurs, 23% technology centres and 5% health sector. Main areas of activities are classified as follows:

- 60% of Bio-Pharma,
- 22% of Bio-Agri,
- 14% of Bio-Industrial,
- 4% of others services.

[10] Sociedad Para La Promocion Y Reconversion Industrial

BioBasque provides to its members financial support and other expertise and also helps start-ups to accelerate growth through networking and access to strategic partners. Strong regional and political supports are involved into the development of biosciences sector. Despite of the fact that the Basque Country was first to implement the strategy from the very beginning the region didn't have critical mass of biotechnology companies. In the beginning they counted on two small multinational pharmaceutical companies and some competencies in bioscience at universities. By trying to take advantage of this situation, the government set a radical diversification strategy (2000-2010) and decided to invest more in knowledge-intensive sectors. As the result of this strategy, the cluster achieved 20% growth in the sector until 2010. In 2012 it had more than 55% of employees in dedicated biotech firms, comparing to total biotechnology employees in the region, indicating that business sector is getting more and more relevance. Their main objective was to foster development of critical mass, but the sector still has many weaknesses such as the lack of quality scientific production and presence of international collaborations. Thus the great efforts of cluster agency remain on carrying out three main areas of activity: knowledge creation, development of the companies and dynamization (more interactions) of the cluster. Moreover, supported by an extensive network of infrastructure and a favourable public administration for the business, cluster agency actively promotes the collaboration between academia, the healthcare system and industry.

BioVal (Valencian Community)

BioVal is an emerging biotechnology cluster. Its scientific base represents a combination of the long-history university of Valencia, several quite young research centres and knowledge institutions. The cluster is relatively young and small in terms of its industrial base. Most of the firms present in the cluster are SMEs. Biotechnology sector is formed by a set of over 50 firms, 4 universities and 14 research centres. It has created around 1.900 jobs in biotechnology sector until 2012 (INE).

Main areas of activities are classified as:

- 33% of Bio-Pharma,
- 32% of Bio-Agri,
- 27% of Bio-Industrial,
- 8% of others services.

Bioval aims to promote the development and competitiveness of the business in bioscience to position its participants on the international map. The most important activities carried out by the cluster agency refer to networking, lobbying and training. Science parks where biotechnology companies are located are well represented in the cluster. However, the cluster does not have a sufficient base of various types of consultants including financial, legal, property and marketing services necessary for its development. Besides the cluster agency is lacking funds and regional government support (as it could be seen later in Table 4). The cluster agency used primarily its website as a communication tool, providing new contents to improve its positioning and visibility; allowing associated companies to count with an active platform about their research and services, facilitating in that way the creation of synergies, and the promotion and sale of their products. It also organizes various activities of information/formation for its participants; such as "Biobreakfast", workshops, conferences and visits to trade fairs to enhance the promotion of cluster actors.

Table 2 summarizes the overview of the clusters and their implemented policies. The relevant information for our case study is extracted from both secondary sources and interviews with policy makers.

Table 2: Basic information on the five clusters and overview of their policies

Name of Regional Cluster	Andalucia Bioregion	Biocat	Madrid Biocluster	Biobasque	Bioval
Location (GDP per capita in €)	Andalusia (16.666)	Catalonia (26.666)	The Community of Madrid (28.915)	The Basque Country (29.959)	The Valencian Community (19.502)
Origin of the cluster (Cluster initiatives is initiated by government, by industry, or equally by both?)	The germ comes from Andalusian government, although there is a business association that is involved in the cluster creation.	Initiated by Catalan Government, although there existed already a fairly strong entrepreneurial base.	Initiative of the six most representative biotechnology companies and three regional public entities.	The strategy was designed and implemented at the behest of the Basque Government to develop bioscience and to create biocluster.	Emerged as an initiative of the industry initiated by several companies.
Initiation of cluster policy implementation	2008	2006	2007	2002	2006
Core Management Organization	As such there is none. IDEA, public agency, dedicated to promote entrepreneurship. Cluster doesn't have a differentiated structure.	Biocat. It is a private organization that has its own governance.	Madrid Biocluster. It's a private non-profit association.	SPRI is 100% public the Basque Business Development Agency until 2010 when biocluster was created as independent organization.	Bioval. More than cluster is an association of biotechnology companies
Number of Employees of Cluster Organization	No employees specifically dedicated to this. Depending on the project, but overall 4 people from IDEA are part time engaged in biotech cluster activities.	15 fulltime dedicated permanent employees, + subcontracts for almost all activities performed by the organization.	3 fulltime dedicated, depending on the project subcontracting of additional employees.	3 (2 in Spri but only 1 fully dedicated which is responsible to align all horizontal services available and 1 in Biocluster).	1 fully dedicated. Before it was 3 when they had more budgets.

Selection of the cluster participants	It's an open approach, voluntary membership of both DBF and users firms.	Any firm in the cluster region which is somehow related to biotechnology R&D is a cluster firm.	Membership fee is required and obligatory for all members including Government, but the amount of the fee depends on the number of employees.	Any firm with activities in bioscience belongs to bioregion. But for new cluster there is a membership fee.	Membership fee is required. From the beginning it was just DBF and recently it includes other organizations related to biotechnology R&D.
Regional potential	Approx. 100 DBF. 10 universities, but 2 are more dedicated to biotechnology related areas. No direct leader firms, some from related industries.	110 DBF 11 universities that offers biosciences; 15 research centres; Several leader firms from pharmaceutical and chemical sector.	70 DBF but not all of them are participating in the cluster; 6 universities (4 active in biotechnology), more than 20 research centres. Several leader firms and multinational companies.	50 DBF, 3 universities, 4 R&D centres (2 specific for bioscience). Four leader firms but comparing on international level quite small.	Almost 50 DBF, 5 universities, 14 research centres. Some potential related industries and end users of biotechnology, but not real leader firm oriented to collaboration.
Total nº of employees in biotech (in DBF)	2509 (769)	6551 (1830)	6421 (1531)	1270 (777)	1917 (435)
Total nº of researchers in biotech (in DBF)	1629 (431)	4422 (1099)	3354 (1045)	970 (531)	1338 (247)
Coordination with other cluster projects	None. Limited to cooperation (partnerships) with few local entities.	Promotion of exchanges with other Catalan clusters; Interest but no concrete interregional cooperation in Spain. Very active in worldwide cooperation.	Active informal exchanges with domestic and foreign organizations and clusters. Partnerships based on the call for projects as cluster organization participate in the European consortia projects.	Coordination of interregional relationship with Aquitania and very informal relationships within region, but still no concrete organizational cooperation.	No concrete organizational cooperation, only informal relationship with some regional associations.

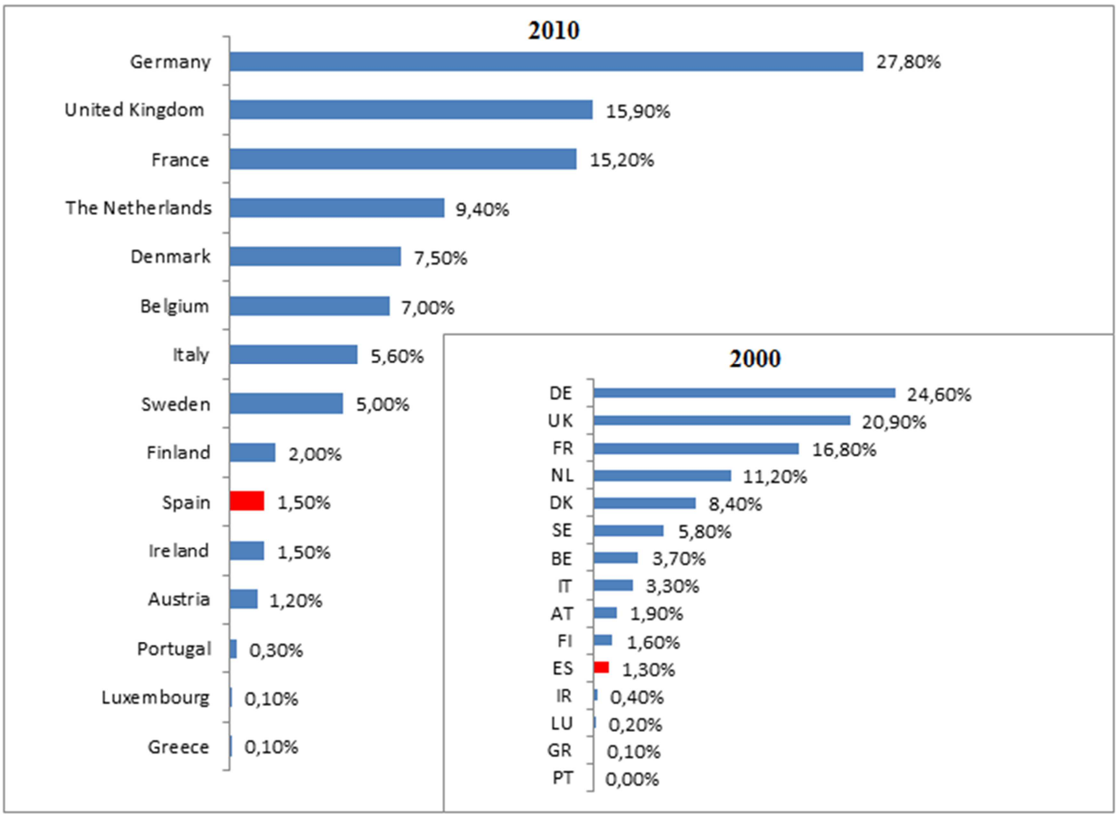
3.2. Technological, scientific and economic evolution of the clusters

3.2.1. Spain in context

According to the latest OECD data as stated in ASEBIO report (2012) Spain is the 2nd country worldwide with the larger number of biotech related companies. More than 3000 companies use biotechnology in some of their processes. Throughout 2000-2010, the number of Spanish biotech companies grew 359% and the number of biotech employees increased by a rate of 37% per year. Furthermore, according to Genoma España Report (2011) Spain's competitive position in science that supports biotechnology developments is high. Also throughout the period 2000-2010 that competitiveness has been increasing; and indeed for the period under review, Spain has increased by 53% its scientific production, to an annual average growth of 4.4%. In the meanwhile growth in the EU-15 and the world has been in the same period around 12% and 21%, respectively, with average annual growth rates of 1.2% and 2.2%. In 2011 Spain produced 3.0% of all global scientific articles in Biosciences, and 9.9% of European scientific production, ranking 4th in Europe and 10th all over the world.

The patent applications and grants are one of the most successful indicators for measuring the transfer of scientific knowledge into products and applications. Although it has experienced some growth in national and international applications recently, overall the indicator of Spanish biotechnology patent applications is still very low. Over the years, the number of patent applications in the Spanish Patent and Trademark Office (SPTO) has doubled thanks to the increased awareness on the relevance of innovation in public institutions, the support and financing program of Genoma España that began in 2005 and the maturation of some biotechnology companies. The average of annual patent applications to the reference period 2000-2010 is 140, starting with 81 applications in 2000 and ending with 212 requests in 2010. According to Genoma España Report (2011) in 2010 the ratio of number of biotechnology patents applied in the SPTO per researcher was around 0.02, double than in 2005 but still insufficient to match Spain with neighbouring countries. Internationally, Spain has also experienced growth, but less pronounced, in its position within the EU-15 it moved from 11th in 2000 to 10th place in 2010. As indicator of international patents, the evolution of the patents granted by the US Patent and Trademark Office from 2000 to 2010 for the countries from EU-15 is shown in Figure 3.

Figure 3: Percentage of biotech patents granted by the USPTO to countries in the EU-15 in 2000 and 2010



Source: Own elaboration from Genoma España 2011 Report.

Following the rationale of this study and within the methodological framework above, we next illustrate comparison of various longitudinal data of five Spanish biotech clusters to assess their performances and other characteristics.

3.2.2. Technological evolution

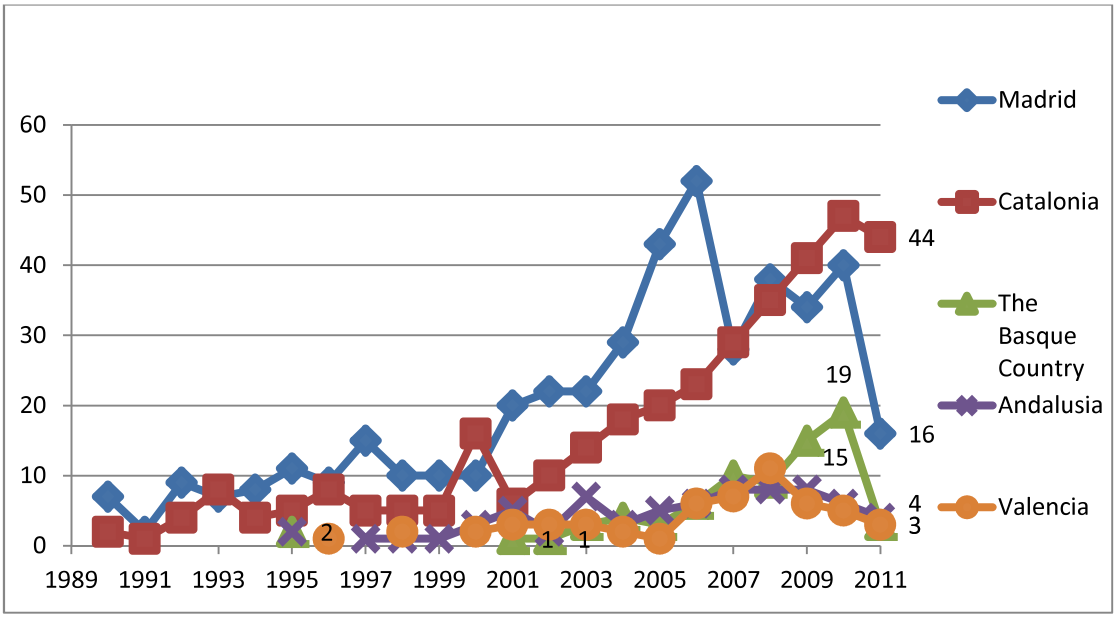
In order to compare Spanish biotech clusters we have derived patent applications from PATSTAT database (version October 2013) on NUTS2 regional level and we have used OECD IPC[11] classes to identify biotechnology patents. Since NUTS2 levels are only available for patents applied in European Patent Office (EPO) our data are limited to

[11] International Patent Classification

them. However we assume that similar trends and distributions among studied regions are present in other patent offices. The selected sample is also relevant if we consider total number of EPO applications for all regions in Spain which until 2011 was 1134 and 993 of them are from the five studied regions, representing 88% of the population.

As we can observe in Figure 4 and 5 there are differences in technological performance measured by patent applications among studied regions. Two groups can be identified. Catalonia and Madrid have started before others and since then they have continued positive trends. Other regions are still performing modestly; the only difference may be noticed in The Basque Country which has succeeded from 2008 to overpass more than 10 patents per year. Regarding the total number of patents present until 2011 we can say that Madrid and Catalonia are holding approximately 5 times more biotech patents than the other three regions. 70 percent of all Spanish biotech technological activities come from these two regions. Besides, Figure 4 indicates that Catalonia is the only region which has been improving steadily over the last ten years. It is clear from the following figures that Madrid and Catalonia outperform in terms of technological performance. In next sections of this study we will analyse how certain facilitators and antecedents are enabling this situation.

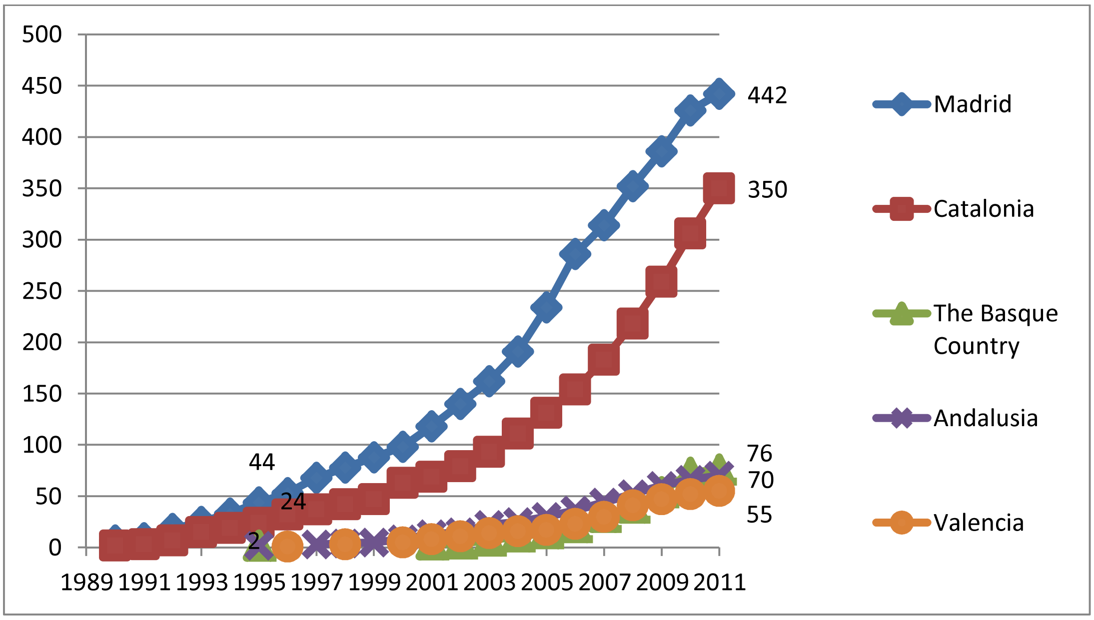
Figure 4: Number of EPO patents (1990-2011)[12]



Source: Own elaboration from PATSTAT version October 2013.

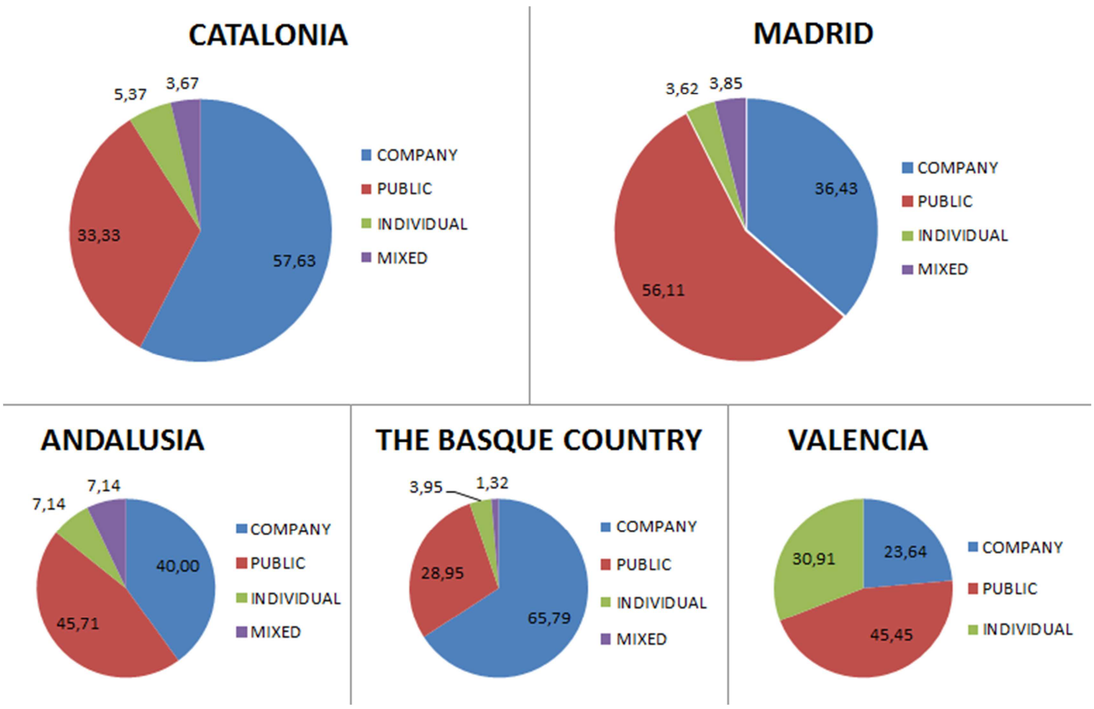
[12] Due to the version of database that we utilized to extract the data for our study, the quality of data for 2011 may be affected.

Figure 5: Trajectory of EPO patents (1990-2011)



Moreover, if we take a look in texture characteristics of EPO patent applicants from studied clusters we observe that there are other differences between them, in terms of the group of actors responsible for the technological development of cluster: business sector, public sector, individuals or combination of some of them. Figure 6 shows EPO patent applicants by sector for the five Spanish biotech clusters until 2011.

Figure 6: EPO patent applicants by sector for five studied clusters

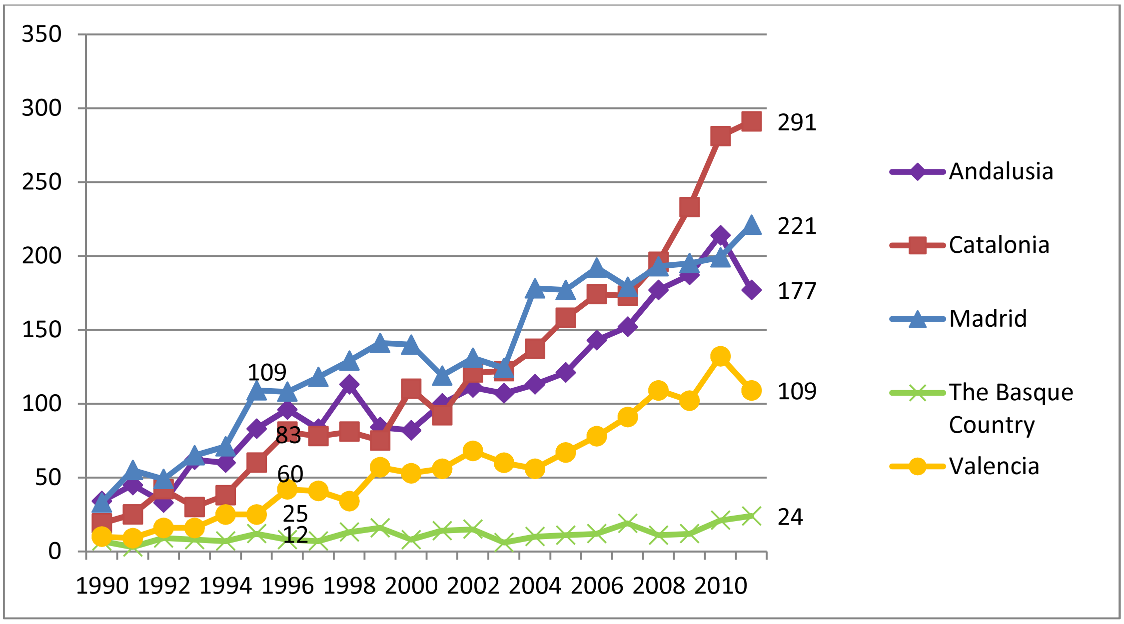


In Catalonia (57,36%) and the Basque Country (65,79%) the majority of patent applicants belong to business, indicating that the industrial sector is playing a dominant role in developing technological innovations. These two regions are also considered among the majority of informants as more entrepreneurial with strong business-minded orientations and a clear focus on markets. Both, in Valencia and Andalusia the public sector is predominant, accounting for 45% of patent applications. The case of Madrid is special. The vast majority of stakeholders from our sample pointed out that data of Madrid could be distorted due to a ‘centralization’ (capital) effect. For instance, the administrative headquarter of the most relevant national research institution (CSIC - the third largest in Europe) is located in this region. It is accounting for 38% of EPO patent applications.

3.2.3. Scientific evolution

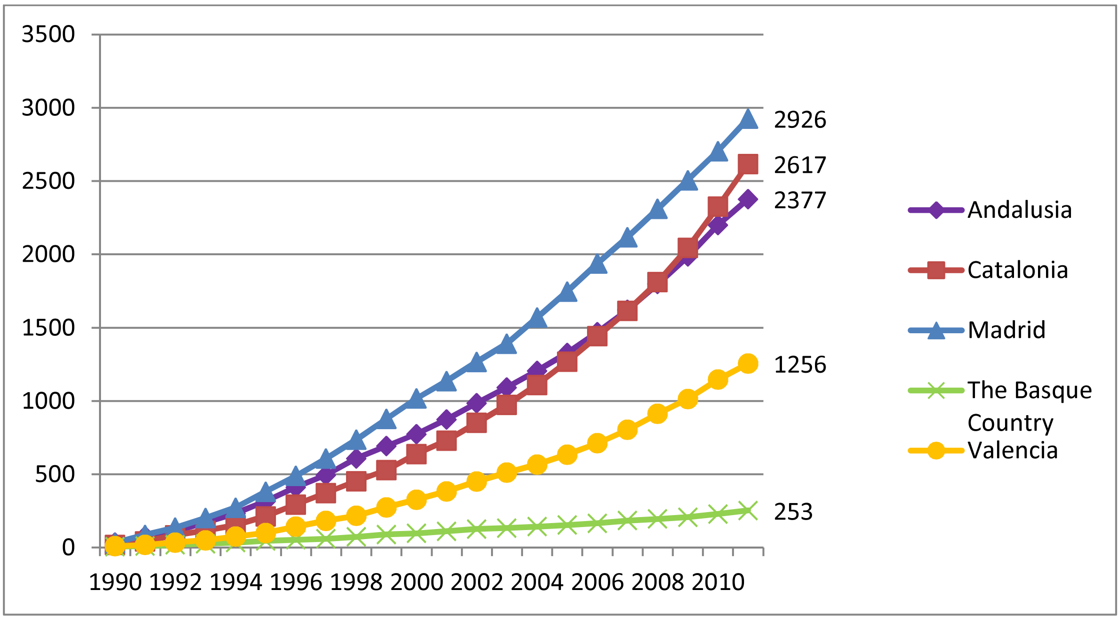
Scientific relevance is measured primarily by the number of articles published in prestigious international journals. For this aim we retrieved bibliographic records from the articles in the database ISI Web of Knowledge, principal collection of Web of Science (WoS), in the research area Biotechnology/Applied Microbiology by year from 1990 to 2011. The procedure of search followed was: in field of address we wrote down the name of each region with all possible variations in the names; subsequently the results were refined by country (Spain) and only articles and reviews have been considered as document types. Thus we have a global view of the evolution of scientific relevance in biotechnology and Figures 7 and 8 compare the number of scientific publications of studied regions and their trajectory, respectively. Several differences among regions are present. On one side, we can see that from 1995 Andalusia, Catalonia and Madrid have experienced significantly growth over the years and these three regions account for 84% of total number of scientific publications. Although Valencia is displaying growth during this period, it is not able to catch up with other regions. On the other side, the level of scientific production of Basque Country is low/moderate and it’s not making any leap in this perspective. Moreover, on Figure 7 we can see clearly that Catalonia is taking the lead from 2008 onwards.

Figure 7: Number of WoS publications (1990-2011)



Source: Own Elaboration from the WoS.

Figure 8: Trajectory of WoS publications (1990-2011)



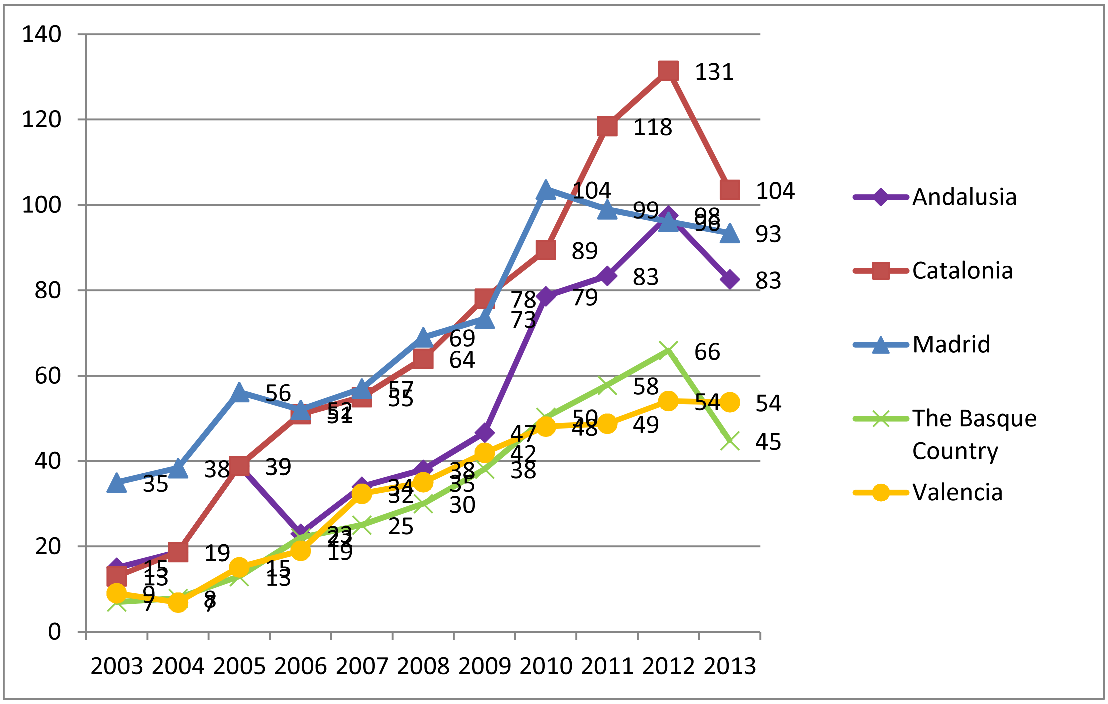
Source: Own Elaboration from the WoS.

3.2.4. Economic evolution

Figure 9 shows how the geographical distribution of Catalonia, Madrid and Andaluisa, (also the leading group in scientific publications) in the number of DBF follows a similar pattern, as three regions represent 74% of the sample. Catalonia ranks first (with

27%), followed by Madrid (25%), Andalusia (22%), followed by Valencia (14%) and the Basque Country (12%). However, here we can see somehow similar trends as mostly all regions have been improving steadily the creation of DBF over the last ten years.

Figure 9: Number of DBF (2003-2013)



Source: Own elaboration from annual ASEBIO reports and National Statistics Institute (INE).

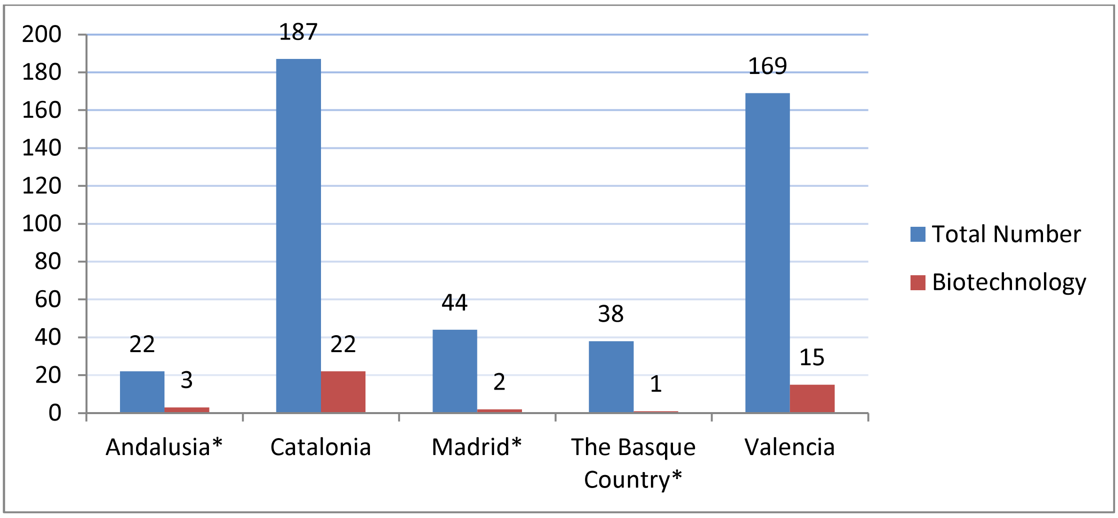
Certainly, the overall trend in the number of DBF has been very positive; it has experienced growth of 478% for the period 2003-2013 going from 79 to 378 companies. Indeed, the number of fully dedicated biotech firms in Spain has been multiplied by almost 5 in a decade. However, we can observe a decrease of 5,3% of the number of created DBF in 2013 comparing to 2012. ASEBIO explains the first decline after 10 years by the difficulty of access to public and private funding and appeal to public policies to accompany the industry consolidation.

According to a study by the Association of Spanish TTO[13], until 2005 in the Spanish public universities it has been created about 380 spin offs. Prior to 2001 there were only 18 spin off, so that pretty all of the university spin off in Spain are post 2001. The same

[13] Technological Transfer Office in Spanish denominated as OTRI

study pointed out that the Polytechnic University of Catalonia and Valencia account for more than a half of the spin-off companies identified in Spain. Figure 10 shows that the Catalan (187) and Valencian (169) universities are the most active in promoting spin-offs; then followed by Madrid (44), the Basque Country and Navarre (38) and Andalusia (22).

Figure 10: Number of university spin offs until 2007



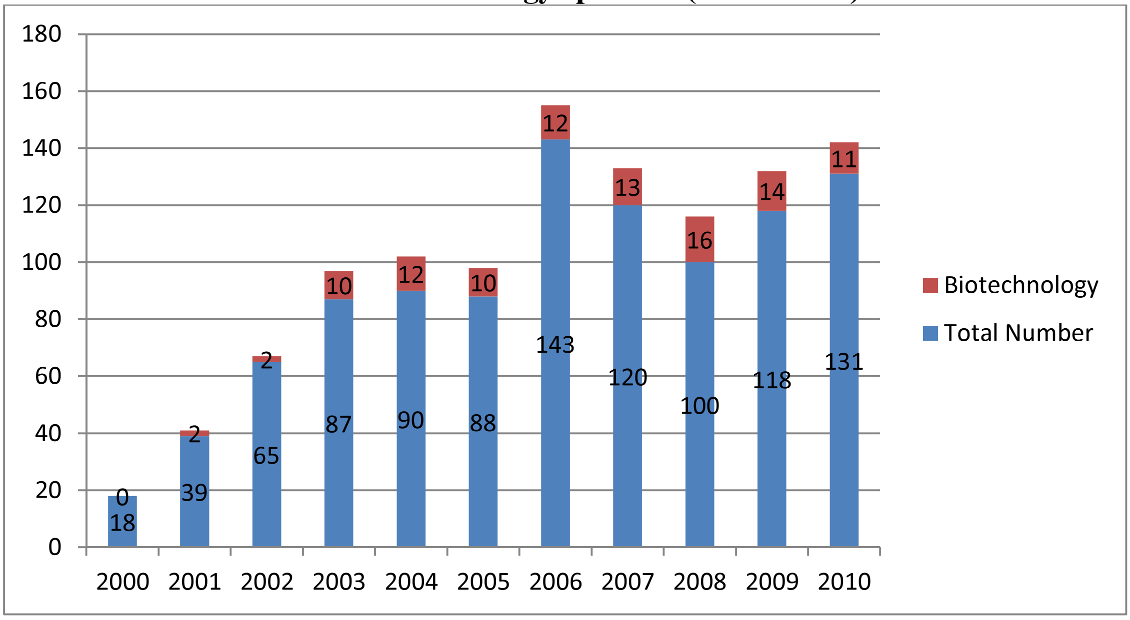
*Some of the data are grouped together with other regions in following way: Andalusia, Extremadura and Murcia; Madrid and Castilla; The Basque Country and Navarra

Source: Own Elaboration / Ortín, P., Salas, V., Trujillo, M. V. & Vendrell, F. (2007). El spinoff universitario en España como modelo de creación de empresas intensivas en tecnología. Madrid: DGPYME.

Column 2 shows the number of biotech spin offs, which represents only 9% of the total number of spin-offs. We couldn't find data of the evolution of biotech spin-offs by region.

The following Figure 11 shows the general tendency of biotech spin-offs in total number of spin-off created. Since the beginnings in 2000, it has been observed a growth trend in the number of spin-offs created from public institutions. In the last two observed years 14 and 11 new spin-offs have been created, respectively, continuing the trend of previous years. The total number of spin offs created in ten-years window is 999 and biotechnology accounts for approx. 10%, in total 102 biotech spin off. The proportion of biotechnology spin offs in total university created spin offs (trajectory along the years) is still pretty the same.

Figure 11: Trajectory of total university and biotechnology spin offs (2000 - 2010)



Source: Own Elaboration / Memoria RedOTRI 2012, (CRUE); Genoma España 2011 Report.

The distribution of public funding for R&D&I and infrastructure is very similar throughout the decade 2000-2010. As shown in Table 3 Madrid and Catalonia account for over 57% of available funding followed by Andalusia with just over 22% in 2010. The Basque Country and Valencia absorb up to 2010 around 10% of public subsidy each.

Table 3: Evolution of distribution of public subsidies (national and regional) for R&D and innovation projects and infrastructure in biotechnology

CLUSTER	Amount in 2000 (millions of euros)	Amount in 2010 (millions of euros)	Annual growth rate (%)*
Andalusia	15,84	83,89	23%
Catalonia	13,38	92,47	24%
Madrid	22,32	125,61	23%
The Basque Country	2,1	39,37	48%
Valencia	9,51	37,25	17%

* Arithmetic average.

Source: Own elaboration from Genoma España 2011 Report.

In respect of the amount provided by the local governments, all of the regions have contributed additional funds to those received from the central administration for R&D&I and infrastructures in biotechnology. The Basque Country and Andalusia stand out here with contributions exceeding 100 million of euros; Madrid and Catalonia between 50 and 100 and Valencia below 50 million of euros. From the relative point of view the Basque Country is the one that makes the biggest effort by its own government as shown in following Table 4.

Table 4: Received and provided subventions for R&D&I projects in biotechnology*

CLUSTER	Amount received from National Government (2000-2010)	Amount provided by Local Government (2000-2010)	Amount Provided vs Received in %
Andalusia	314.946.269	173.808.180	55%
Catalonia	660.624.118	51.625.345	8%
Madrid	698.188.299	99.174.433	14%
The Basque Country	82.288.917	204.531.047	249%
Valencia	220.492.523	38.469.396	17%

*EU subventions not included.

Source: Own elaboration from Genoma España 2011 Report.

4. DISCUSSION - Performance differences where might they come from?

As it has been described throughout this study Catalonia counts on the greatest number of DBF. This cluster also accounts for the largest presence of important international pharmaceutical companies acting as anchor tenants (i.e. Grifols, Pfizer-Fort Dodge, etc.). It also has advantages from the entrepreneurial orientation of its universities and recognized research centres located in the region. Firms from Catalonia argued that besides their internal strategy and targeting, another important element of the strategy for technological development is the adoption of open innovation practices. The existence of scientific parks (such as PCB) which provide access to powerful network of collaborators and scientific excellence makes it easier. Moreover the cluster agency has deployed a very proactive strategy with a clear international orientation.

Biocat stimulates interaction between universities, hospitals, research centres and industry environment, covering all areas, from basic research to clinical. This facilitates the growth of local pharmaceutical and biotechnology companies in areas of great opportunity in order to create a strong and competitive business and also attracts international companies. Biocat is the only one that emphasizes the importance of driving properly technological transfer in order to get benefits of patents for all agents involved allowing the funding of new research projects. Also it is the only one which counts on specific model for attracting talents (Open Talent Recruitment Program). In respect of talent, an outstanding example of policy support is the ICREA initiative, set by the Catalan government. ICREA (Catalan Institute for Research and Advanced Studies) is part of the Talència institution which was created in 2001 to provide new forms of contracting that allow it to compete with other research systems, and hire top scientists to Catalonia, in close collaboration with universities and research centres by long-term agreements that integrate new researchers. They are still pending to provide better scientific base that will produce quality applied science and real connections between basic science and market needs through effective collaborations between science and industry actors to achieve greater competitiveness on international level. Almost all interviewees gave a lot of relevance to Biocat as an organization which has become a central catalyst for the business projects and drives the sector in the right way with available resources. However they remarked the lack of funds from the regional government and plea for more direct investment in R&D in biotechnology. Both Catalan informants claimed the similar:

> *"Biocat is important; it acts as an intermediary between the government and industry."*

Madrid has a strong science base represented by many recognized research centres and university and great amount of scientific publications. Also, its environment is very open as witnessed by the high number of international companies. The vast majority of informants see Madrid with more developed structural factors, such as communications and services, infrastructure and equipment, which promotes the flow of goods and attract more the population to settle in these areas. It also attracts entrepreneurs and investors from outside the region, and there is a great concentration of state civil services. National Decision-making centres are nearby and access to industrial land is good. But still there are aspects to strengthen in order to create more competitive base, as the entrepreneurial capacity, lack of talents and oriented leaders to collaborate and build stronger networks. Success depends on the ability to generate initiatives to promote entrepreneurship within the region and foster the entrepreneurial orientation of universities in order to give the practical application of knowledge and necessary direct promotion of technology transfer. The economy based on knowledge and innovation cannot be improvised. A more proactive strategy of the cluster is needed to be truly competitive in the European and global level. Both companies from Madrid pointed out that networking and collaborations within the region is not exploited and that regional agencies are not very active in maximizing the available resources and all potential for biotech and related companies located in the region. One of the interviewed directors considers that Madrid Biocluster is not a relevant organization. Another considers (networks of) collaborations between different stakeholders crucial for technological innovation and the growth of biotechnology sector and complained about the role of cluster agency:

> *"Madrid Biocluster has never contacted us nor offered us to be part of their project."*

Our informants state that Madrid Biocluster as an organization that promotes bioregion should make efforts to include all existing actors from the region into the network and support the overall biotech sector. As a regional cluster policy it lacks a clear strategy and initiatives to launch programs that respond the need of a critical mass of small business units able to drive innovation and to encourage the creation of public-private partnerships (PPP) in biotechnology sector.

All interviewees have seen clear potential in BioBasque strategy and they strongly believe that this cluster is going to grow rapidly in the future. They have very good management which is fostering a lot the strong network within a region and are able to maximize all resources they are counting. Although the number of biotech firm is scarce, some relatively large companies are located in the cluster. Also, this is a region of entrepreneurs and the government has a clear vision to invest in R&D which enables the creation of new knowledge, technologies and innovations, but this is a long-term project and it needs time to reflect in the results all invested resources. The interviewed firms from the Basque Country consider essential to find the way to obtain grants for already established biotech firms which will enter the second round of financing. The focus should be on both, the number of companies created, and the number of consolidated companies which may achieve breakeven at least. *"From seed to fruit is the tree pin which must be looked after"*, says one of our informants. Despite the fact that the Basque Country was a pioneer to implement the cluster policy strategy in Spain, they clearly lacked industrial and scientific driving forces to enjoy the first mover advantage. This is still young and small cluster and there is continues necessity to promote more international cooperation in order to improve both, science and industry.

Andalusia Bioregion and Bioval reflect very similar situations. Although they don't count on the same resources, the barriers highlighted by our respondents are very similar, allowing us to put them in the same group. Traditionally in these two regions the industry has shown a family business vision, focusing on traditional activities, such as agriculture or manufacture. Thus it's difficult to promote an innovative activity over extended time frames and requires intensive and prolonged funding. Although the entrepreneurial culture is present in Bioval considerable effort is still required to bring the current entrepreneurial spirit to a higher level. Bioval could take advantage of the presence of entrepreneurial universities in the region. However it's important to highlight here that experts from technological transfer offices[14] are claiming that Spanish university spin-offs are constantly having troubles to find ways for growing and facing business development. The culture of risk aversion, a lack of local venture capital and regulatory loads are factors which limit the development of cluster.

Anchor tenant firms for the sector are not present in these two clusters. However, both have potential end users of biotechnology, which could act as leaders in launching new products, because of its size and activity, but this call for more promotion and encouragement to add bio initiatives throughout the region. Here, the regional governments have very important role to play. However, cluster agencies have not deployed a formal strategic plan for favouring an environment conducive to the consolidation of new technological advances. Although they have promoted policies of financial support to technological development, the co-financing has been in excess fragmented and has not promoted a culture of innovation in potential recipients organizations or driving of technology products in society. According to our informants

[14] Annual Report of RedOTRI (2012)

the institutional environment in general does not perceive the private entrepreneur as a driver of technological advancement. Moreover, there is a tendency to consider that “the project is the goal” for the sole purpose of finding funding to maintain a dynamic of work. This approach is away from market and is still too widespread in the public administration. This mentality must change to increase competitiveness. One of interviewed directors pointed out that:

> *“The institutions representing citizens and are serving them, so they have an inescapable responsibility to facilitate access to technological advances that contribute to the welfare of society.”*

Three out of four companies’ respondents from these two clusters have drawn attention that Valencia and Andalusia might be subjects of a high rate of corruption in recent years. They argued that if money does not go where it should and decision centres are installed in ‘comfort zones’ neither the results come and no progress is favoured. The proliferation of intermediate agents in the innovation ecosystem does not correspond to the still small number of innovators. Investment in ‘brick’ must give way to investment in ‘talent’. Infrastructure and equipment should be necessary, but not excessive; it has to respond to strategic planning. It seems that in these two clusters there is a very high structure cost to maintain the intermediate segment and a loss of efficiency occurs. One of the respondents highlighted that there is an overbooking of infrastructures and the transformation is needed:

> *“There is much good but little related.”*

The culture of cooperation and commitment has to be fostered. Without that spirit of cooperation and willingness to integrate companies into existing scientific parks and including active role of the whole university system, the scientific parks risk to become reduced to renting space and physical services. Although Andalusia has the high number of DBF, the indicator shouldn’t be the number of start-up companies created annually, but the proportion of start-up getting evolved to grow-up in a reasonable period of time. In this sense, the regional agencies should provide the support and the adjusted solutions to the industry. As one of the CEOs stressed:

> *“In a healthy innovation ecosystem, the most common figure should be the entrepreneur, not the agents that move around it.”*

The public sector must identify itself with the entrepreneur in achieving the market objectives, a long-term vision of it, agreeing about time and adequate resources, beyond a purely academic horizon. The institutional framework should promote access of technologies to market. Both clusters are still focused on only local partnerships and no concrete national nor international cooperation exist.

The following Table 5 summarizes the previous described findings from our case study and identifies the different facilitators present in each cluster.

Table 5: Presence of facilitators in five studied clusters

	INDUSTRIAL DRIVING FORCES		SCIENTIFIC DRIVING FORCES		SUPPORTING DRIVING FORCES			
	Critical Mass	Anchor Tenant Firm	Entrepreneurial Orientation of Universities	Recognized Research Centres	Active role of Cluster Agency	International Orientation	Entrepreneurs	First Mover Advantage
Andalusia	X							
Catalonia	X	X	X	X	X	X	X	
Madrid	X	X		X		X		
The Basque Country		X			X		X	X
Valencia			X				X	

These three factors are very complementary and represent the appropriate base for creation of new knowledge and technologies. It becomes clear that within the two 'leading' regions (Madrid/Catalonia), all three components are better developed, more present. Other regions lack some or the majority of facilitators. We propose that in every cluster these three factors have to be present with their appropriate facilitators in order to represent potential for knowledge exchanges and generation of innovation to achieve competitive results and growth.

5. CONCLUSIONS

The knowledge-based economy is making its way, even becomes a priority challenge, for example, in EU policy. In this sense, fostering relationships between university, industry and administration are not only justified theoretically but also economically favouring allocation of budget items, develop driving initiatives, strength commitments, etc. In this line, the concept of 'innovation systems' has gained widespread acceptance and has been used as a general framework for designing innovation policies and adequate institutional arrangements in order to support growth objectives in new, knowledge-intensive economic activities (OECD, 1999).

A sectorial cluster of any kind involves the association of institutions based on common interests and complementarities. Our discussion speaks to the research on biotechnology clusters as well as the local government policies addressed to foster knowledge creation and transfer in knowledge-intensive industries. A multiple case study completed showed that context enables different trends of technological development and presence of different cluster facilitators has clear influence on evolution of biotech clusters. Our work suggests that three driving forces have to be present and well interconnected for the success of regional cluster. These are: supporting driving forces, industrial driving forces and scientific driving forces.

These three factors are very complementary and represent the appropriate base for the creation of new knowledge and technologies. Also, reflecting in this way similarities with the triple helix model of regional policies which propose that three group of actors should be well connected (industry, science, administration) to achieve innovation performance. Findings from our study recommend that three factors at cluster level are representing potential for knowledge exchanges and innovation of biotech industry.

Clusters represent a context with numerous opportunities to share knowledge. However, a model of international success of cluster as a favourable context for innovation has to have all the potential that strategic sector requires: political participation, a diverse and competitive business, entrepreneurship, critical mass of researchers and companies, prestigious universities, excellent level of innovation and dedication of all stakeholders involved. The recipe is based on the coexistence of all the ingredients for a core of innovation: scientific research capabilities over the standard, a dynamic industrial sector with competitive elements aligned to a cooperation strategy, supportive government policies and detection of opportunities facing the future.

The strength of the biotech cluster attracts collaborators from other systems (Levitte et al, 2010). Acknowledging the benefits accumulated from university–biotechnology relationships, governments in the US, Canada, Japan, EU and other emerging and developing nations invest in such linkages. The principal assumption is that governments that invest in their universities' research will stimulate innovation, attracting industrial R&D and increasing its productivity (Levitte et al., 2010). Governments should also put in place programs to promote university - biotechnology partnerships.

Universities and public research institutions are an important source of knowledge in biotechnology and often act as a catalyst for private sector development through licensing of technology to the biotechnology industry and promoting the creation of spin-off. The development of the biotechnology industry as innovator and as an economic engine depends largely on exploiting research results generated in the public sector, through the transfer to the private sector. The transition from lab to market with tangible products that improve the quality of life of people is a reality. The commitment to the generation of an industrial sector based on innovation leads to economic development and the generation of skilled employment; and through good management of R&D generated in universities and public research institutions, can ensure economic return on public investment in R&D. The Spanish biotechnology industry's main actors of knowledge creation are universities and public research centres. Thus, there is high importance to promote public-private partnership for the development of Spanish biotechnology sector. Achieving these goals requires adequate public and private investment initiative, with increased budgets for R&D or improved uptake of European funds.

Policy makers should be aware that some agents perceive a low sensitivity of government to the sector. Even if the strategic policies have been developed and implemented in all regions, some of them are not proactive nor pursued in the best manner. The regional governments have to be aware of the important role they can play in the development of their regions and promotion of interconnections between all actors must be based on real market needs for a higher level of innovation performance and progress in technological achievements. Aids must be stable and continuous over time, unaffected by changes in the parties of the government, so that companies may incorporate necessary resources to pursue their innovation strategies in the long term. It's important to recognize the necessity to take the technology to market and develop proper initiatives to foster the PPP to increase competitiveness of regions on global level.

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CHAPTER VI

CONCLUSIONS

The fundamental question that inspired this dissertation was *which enablers should be present at the level of firms, alliances and clusters, in order to improve the innovation performance of companies*. To answer this ambitious question, four studies were carried out. The following sub-questions have been driving each of those studies:

i) How the diversity of partners in a certain alliance for innovation affects innovation performance, and how this influence can be moderated by certain features of the own alliance.
ii) Whether and how firms' alliance portfolio configuration determines scientific and technological performance and contributes to the growth of small and medium sized firms.
iii) What is the role of firm's scientific capabilities for technological innovation, in interaction with science/industry relationships?
iv) How industrial, scientific and supporting driving forces enable technological development within cluster?

Regarding the first question our research suggests a curvilinear relationship between alliance partner diversity on innovation performance, similarly to previous literature that highlights both, the opportunities and the hindrances of diversity (de Leeuw et al., 2014; Duysters and Loksing, 2011; Laursen and Salter, 2006; Sampson, 2007; Oerlemans et al., 2013). Although we have not been able to strongly confirm the inverted u-shaped relationship, it seems that firms can reap more benefits from their innovation alliance when the level of partner diversity is moderated. Besides, our research suggests that the study of alliance partner diversity, as determinant of alliance performance, should not be addressed in isolation. By considering some moderating effects, the influence of having diverse partners on innovation performance can be better understood. In this sense, relational social capital and knowledge codifiability, as moderating variables, help reap the benefits of alliance partner diversity.

In the second research question we inquired about the characteristics of alliance portfolio configuration and their impact on firm performance. It seems that firm performance is not driven by the mere size of firms' alliance portfolios. Rather, the organizational and geographic features of the alliance portfolios influence technological performance, which in turn affects the growth of the firm. In terms of alliance types, exploration alliances – or alliances of a 'scientific' nature – are more effective and influential than exploitation-oriented alliances for technological performance of biotech firms. Besides, both local and international dimension within the alliance portfolio help to improve technological performance. In the local context, alliances with knowledge-generating institutes are especially effective. In the international context, the presence of business partners in portfolio contributes to technological development. We underline that firm's alliance portfolio only has direct impact on its technological performance, which in turn influences economic growth. Interesting findings are provided in terms of tight relationship between science and technology what has inspired us to research more in depth on this topic.

Regarding our third research question, we examined the effect of "make&buy" knowledge decision on firm's technological innovation. Firm's scientific capabilities are indeed important for technological development. However, in knowledge-intensive industries, as biotech is, this internal approach can be substantially leveraged by means of interactions with knowledge generating institutes. The proximity to these agents even improves the benefits of such relationships, by making easier the exchange of complex and tacit knowledge. Thus, to combine the creation of internal scientific knowledge ("make") with the exchange of knowledge with local research institutions ("buy") seems to be a favourable strategy for innovative firms.

Our fourth research question tried to explain how certain variables at the cluster level may enable technological development of the firms located in the cluster. We grouped these variables in three factors named industrial, scientific and supporting driving forces. Regarding industrial driving forces, the existence of a critical mass can enable local firms to access to more knowledge exchanging opportunities. Besides, the presence of anchor tenant firms injects dynamism in the region, strengthens the industrial base, encourages collaboration between local biotech companies and improves their visibility on international perspective. Scientific driving forces have to do with the presence of universities and research centres, with both capacity to build a strong scientific base and capability to transfer knowledge to the industry. Thus, tight interactions with industry become crucial for creating cluster knowledge creation capabilities. The existence of spin-offs is also a remarkable indicator of these scientific driving forces. Moreover, the local capacity of scientific and technological discovery is able to attract more qualified researchers from other systems, as well as to raise investments and funding opportunities. Supporting driving forces include, among others, the presence of a cluster agency that coordinates and encourages knowledge exchanges in the region and play a pivotal role in the cluster development. It seems an imperative to have a well-organized management team with a clear vision to provide basic platform for all the stakeholders in the area. Their initiatives can create an environment with a strong research system, active transfer of knowledge and an entrepreneur ecosystem, all of which contributes to the wellbeing of society as a whole. Well defined local innovation system and policies in line with biocluster's strategies will promote collaborations among all its participants and combining the synergies of triple helix model (public administration-knowledge generating institutes-industrial sector) stimulates the innovation.

We contribute to the current research on innovation in several ways. First, we provide empirical evidence on why some alliances for innovation perform better than others. The relevance of involving contingent effect while studying the impact of alliances on innovation is confirmed. Two alliance attributes related to the quality of relationships and the type of knowledge shared among partners, are highlighted as enablers of easy knowledge transfer between diverse partners. Second, our study provides a more comprehensive understanding of how alliance portfolio configuration can influence innovation performance. Third, we add to the research of innovation strategy the benefits of complementarities between internal and external research activities, in the same time, giving emphasize to science-industry interactions. Besides, how firms' scientific capabilities enable them to benefit from such relationships is underlined. Forth, at cluster level, the importance of presence of different enablers for innovation is confirmed, enriching in that way the research on this topic. Summarizing, we contribute to the research on innovation management by bringing together enablers of innovation at level of firms, alliances and clusters. Enablers at different levels can contribute to improve efficiency of knowledge exchanges in networks which would be reflected in better innovation performance of small and medium biotech firms.

Relevant implications for managers and policy makers can be derived from this dissertation. Managers can reduce the problems of having diverse partners in alliances by promoting close and trustful relationships and trying to codify the shared knowledge. Entrepreneurial firms aiming to become competitive at broader scale have to maintain the local alliances with knowledge generating institutes but also to access to the latest knowledge available from international business partner. Policy makers have to be aware about the importance of science-industry linkages for technological development. Moreover, regional governments should play an important role by providing resources and initiatives necessary to create a favourable climate for innovation.

Our research also has confronted several limitations. Some of our conclusions may be limited and interpreted with caution as we have only analysed biotechnology industry which may differ from other industries because it is highly science-based. The generalization of our results is also scarce as we have only focused on the Spanish context, so far. For further research, it could be interesting to compare it with other European regions. Also, we could improve the sample of our study as in some models we count with limited number of observations. This dissertation has taken into account a limited number of variables. Further analysis could examine new variables or measures such as number of developed products, alliance management capabilities and other features of firms, alliances and clusters.

Finally, we underline once again that an important stock of knowledge is generated at three different levels, which are firms, alliances and clusters. Still, these three levels are tightly related, namely the permeability between them enables the stock of available knowledge into one level feedback each subsequent levels. Thus, the available knowledge on the cluster enriches the knowledge transfer in the networks and alliances that, in turn, will increase the knowledge of individual company. This flow of knowledge between levels is also circulating in reverse, as the knowledge generated in the company, improves the shared knowledge in alliances and collaborative networking, and this increases the knowledge available in cluster. Our future research is interested in approximation of this permeability in more details.

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APPENDICES

Appendices A: from the chapter II

Appendices B: from the chapter III

Appendices C: questionnaire

Appendix A.1: Factor analysis

	SC	KC	IP
Social Capital (Inkpen and Tsang, 2005; Maurer and Ebers, 2006; Molina and Martinez 2009, 2010) (Cronbach's alpha. 0.894)			
SC1: We share the same goals and interests in joint projects.	.73		
SC2: We are motivated to pursue collective goals in joint projects.	.75		
SC3: There is a shared vision on the environment and the key factors of success.	.74		
SC4: We believe that the future of our company is related to companies with whom we have established an alliance.	.51		
SC5: We have developed some type of strategy or common plan for joint projects.	.85		
SC6: We trust that the companies with whom we are in partnership do not take advantage of the alliance or behave opportunistically.	.86		
SC7: Companies with whom we have the alliance maintained the commitments made.	.88		
SC8: We are sure that there will be agreement, even when there is not a written contract that specifies the obligations of each party.	.85		
SC9: In general, there is a climate of cooperation and mutual trust among the participants.	.87		
SC10: We feel a special obligation to be supported in difficult situations and to support each other.	.66		
Knowledge Codifiability (Kogut and Zander, 1995; Subramaniam and Venkatraman, 2001) (Cronbach's alpha. 0.844)			
KC1: There exists a useful manual that describes the processes.		.82	
KC2: The information and decision rules are stored in electronic databases.		.78	
KC3: Knowledge about the alliance is sufficiently explained in writing.		.80	
KC4: New staff can learn easily talking to staff involved in the alliance.		.67	
KC5: New staff can learn easily by studying the existing manual.		.86	
Innovation Performance (Rese and Baier, 2011) (Cronbach's alpha. 0.811)			
IP1: Because of the innovations new markets could be opened.			.69
IP2: Because of the innovations other new products became possible.			.58
IP3: The innovations were technically successful.			.68
IP4: The schedule was met.			.76
IP5: The budget was met.			.68
IP6: Time was used efficiently.			.76
IP7: Quality specifications were met.			.69
Eigenvalues	5.57	3.10	3.36
Explained Variance	55.66	62.01	47.95

Appendix A.2: Robustness test with different measurement of the alliance partner diversity

We have used different measure of alliance partner diversity to check for robustness of our results. The variable alliance partner diversity was calculated by dividing the number of partner categories firm has by the maximum number of partner categories. The measurement used here is exactly the same one used in previous studies (Duysters and Lokshin, 2011; Oerlemans et al., 2013; de Leeuw et al., 2014).

Dependent variables	Base Model β		Model 1 β		Model 2 β		Model 3 β		Model 4 β		Model 5 β		Model 6 β		Model 7 β	
Control variables																
Cluster1	-0,86	*	-0,88	**	-0,80	*	-0,27		-0,27		-0,23		-0,26		-0,29	
Cluster2	-0,85	*	-0,82	*	-0,83	*	-0,15		-0,15		-0,12		-0,16		-0,21	
Cluster 3	-0,87	*	-0,87	*	-0,79	*	-0,45		-0,45		-0,38		-0,45		-0,43	
Cluster 4	-0,75	†	-0,74	†	-0,75	*	-0,28		-0,28		-0,23		-0,29		-0,32	
Age	0,01		0,02		0,02		0,01		0,01		0,01		0,01		0,01	
Size	0,00		0,00		0,00		0,00		0,00		0,00		0,00		0,00	
R&D	0,00		0,00		0,00		0,00		0,00		0,00		0,00		0,00	
Leader	0,10		-0,05		-0,09		0,14		0,14		0,18		0,14		0,12	
Main effect variables																
Diversity			-1,87	**	2,38		-0,18		-0,30		-20,29	*	0,68		29,06	†
$Diversity^2$					-5,66	†	-1,56		-1,50		25,17	*	-1,41		-53,39	†
Social Capital							0,51	***	0,50	**	-0,05		0,51	***	0,51	***
Codifiability							0,20	***	0,20	***	0,19	***	0,24		0,85	*
Interactions																
Div X CS									0,02		4,01	*				
Div^2 X CS											-5,51	*				
Div X Cod													-0,19		-5,38	†
Div^2 X Cod															9,54	†
Model																
R^2	0,11		0,18		0,21		0,57		0,57		0,60		0,57		0,59	
Adjusted R^2	0,02		0,09	†	0,11	*	0,51	***	0,50	***	0,53	***	0,50	***	0,51	***
F statistic	1,21		1,94		2,08		8,61		7,85		8,04		7,86		7,68	
ΔR^2			0,07	**	0,03	†	0,36	***	0,00		0,03	*	0,00		0,02	†
Change in F			7,05		2,91		32,90		0,00		5,04		0,08		2,81	

Two-tailed tested. † p < .1; * p < .05; ** p < .01; *** p < .001; *** High-performance work practices;

Appendix A.3: Robustness check for S-shaped relationship between alliance partner diversity and innovation performance

In order to see if our data follows an inverted U-shaped we have also calculated the robustness test of X^3 regarding to Haans et al. (2015). Once we added a cubing term to alliance partner diversity variable our test shows that there is no improvements in model fit what suggest stronger support for quadratic relationship.

Dependent variables	Base Model β		Model 1 β		Model 2 β		Model 3 β	
Control variables								
Cluster1	-0,86	*	-0,89	**	-0,82	*	-0,85	**
Cluster2	-0,85	*	-0,83	*	-0,85	*	-0,88	**
Cluster 3	-0,87	*	-0,88	*	-0,80	*	-0,80	*
Cluster 4	-0,75	†	-0,75	†	-0,77	*	-0,81	*
Age	0,01		0,02		0,02		0,02	
Size	0,00		0,00		0,00		0,00	
R&D	0,00		0,00		0,00		0,00	
Leader	0,10		-0,06		-0,10		-0,09	
Main effect variables								
Diversity			-1,79	**	2,12		14,77	
Diversity^2					-4,95	†	-37,54	
Diversity^3							23,55	
Model								
R^2	0,11		0,18		0,21		0,23	
Adjusted R^2	0,02		0,09	*	0,11	*	0,12	*
F statistic	1,21		2,00		2,14		2,14	
^R^2			0,08	**	0,03	†	0,02	
Change in F			7,51		2,96		1,89	

Two-tailed tested. † $p < .1$; * $p < .05$; ** $p < .01$; *** $p < .001$;

Appendix B.1: Causality check between alliances and technological performance

In order to see if our data and their effects follow correct causality we have examined several tests. First, we have used linear regression to confirm if the fact that firm has patents in period before (from 2000 to 2008) led it to establish greater number of alliances and/or subsequently more exploration alliances. Both of them were used as a dependent variable and control variables from previous analyses are the same ones. Second, we considered if firm had at least one international business partner in its alliance portfolio from 2008 to 2012 as dependent variable in the model while previous patenting (period from 2000 to 2008) was used as main explanatory variable. We have also controlled for the same variables as in previous analyses plus total number of alliances firm had from 2008 to 2012. As our dependent is dichotomous variable logistic regression was performed. As we didn't find statistically significant result we conclude that alliances from our sample are predicting patenting and not vice versa.

	Model			Model		
	Total Number of Alliances			Exploration-based Alliances		
Variables	**Coefficient**		**t statistic**	**Coefficient**		**t statistic**
Constant	2,40		0,56	1,00		0,43
Cluster	5,76		1,74	1,96		1,10
Size	3,12		1,69	1,78		1,79
Part of MNC	-3,05		-0,52	-4,76		-1,53
Previous Patents	-3,90		-0,92	-0,97		-0,42
Previous Publications	6,51	*	2,48	3,45	*	2,45
Model						
R^2	0,19			0,13		
Adjusted R^2	0,13	**		0,10	**	
F statistic			3,42			2,74
$\wedge R^2$						
Change in F						

Significance levels * p < 0.05; ** p < 0.01; ***p < 0.001; Two-tailed tests.

Variables	Base Model		Model 1	
	Coefficient		Coefficient	
Control variables				
Cluster	0,23		0,13	
	(0,17)		(0,05)	
Size	1,17		1,23	
	(1,45)		(1,59)	
Part of MNC	0,17		0,08	
	(0,31)		(0,07)	
Previous Publications	0,53		0,52	
	(1,12)		(1,03)	
Number of Alliances	0,08	*	0,08	*
	(5,14)		(5,35)	
Main effect variables				
Previous Patents			0,97	
			(1,93)	
Model				
Number of observations	79,00		79,00	
Nagelkerke R Square	0,29		0,32	
Likelihood Ratio Chi Square	19,48	**	21,47	**
Random Model Classification Rate	57%		57%	
Overall Classification Rate	70%		70%	

*Significance levels * $p < 0.05$; ** $p < 0.01$; ***$p < 0.001$; Two-tailed tests. Wald statistics are in parentheses.*

Appendix B.2: Robustness test of exploration-based alliances

We have used different measure of exploration alliance to check for robustness of our results. The variable of exploration-based alliances was calculated as a proportion of number of alliances firm has with knowledge generating institutes in its alliance portfolio (total number of alliances). Furthermore the squared term of exploration-based alliance variable is calculated and introduced in the hierarchical regression model in order to test for curvilinear relationship. The results of this robustness tests are showing an inverted U-shaped relationship between exploration-based alliances and patenting activities suggesting that moderate level of alliances with knowledge generating institutes will be optimal for technological performance.

	Base Model		**Model 1**		**Model 2**	
Variables	**Coefficient**		**Coefficient**		**Coefficient**	
Control variables						
Cluster	1,39	*	1,47	*	1,92	*
	(5,13)		(4,73)		(5,71)	
Size	0,28		0,16		0,27	
	(0,65)		(0,21)		(0,53)	
Part of MNC	0,26		0,45		0,01	
	(0,07)		(0,22)		(0,00)	
Previous Patents	2,02	**	1,92	**	2,56	**
	(6,78)		(5,80)		(7,71)	
Previous Publications	1,61	*	1,62	*	2,42	**
	(5,29)		(4,54)		(7,65)	
Main effect variables						
Number of Alliances			0,02		0,00	
			(0,45)		(0,03)	
Exploration Alliances			0,66	*	1,79	**
			(3,76)		(8,15)	
Exploration Alliances^2					-1,16	**
					(6,12)	
Model						
Number of observations	79,00		79,00		79,00	
Nagelkerke R Square	0,42		0,47		0,56	
Likelihood Ratio Chi Square	29,25	***	33,60	***	41,62	***
Random Model Classification Rate	62%		62%		62%	
Overall Classification Rate	73%		73%		81%	

*Significance levels * $p < 0.05$; ** $p < 0.01$; ***$p < 0.001$; Two-tailed tests. Wald statistics are in parentheses.*

Appendix C.1: Questionnaire[15]

I. INFORMACIÓN GENERAL

P1. Información general sobre la persona que responde al cuestionario:

P1.1. Puesto que ocupa en la empresa:	
P1.2. Años de experiencia laboral en el sector de la biotecnología:	P1.3. Años de experiencia en esta empresa:
P1.4. Rellene la siguiente tabla con sus datos:	

Sexo	**Edad**	**Nivel de estudios**
Hombre ☐ (1)	Menos de 24 años ☐ (1)	Sin estudios ☐ (1)
Mujer ☐ (2)	25-34 años ☐ (2)	Estudios primarios ☐ (2)
	35-44 años ☐ (3)	Estudios secundarios ☐ (3)
	45-54 años ☐ (4)	F. P. de grado superior ☐ (4)
	55-64 años ☐ (5)	Carrera universitaria ☐ (5)
	65 años o más ☐ (6)	Postgrado o doctorado ☐ (6)
		Indique la carrera universitaria:
		Indique la especialidad del doctorado:

P2. Información general sobre la empresa:

P2.1. Nombre de la empresa:			P2.2. C.I.F.	P2.3. Año de fundación
P2.4. Actividad principal de la empresa:				
P2.5. Indique con una X los campos de actividad de la biotecnología en los que se encuadra su empresa:				
a. Industrial/medioambiental:	b. Agroalimentaria:	c. Sanitaria (salud humana y animal):	d. Bioinformática:	e. Servicios y otros:
P2.6. Nº total de empleados fijos (aprox.)		P2.7. Número de empleados implicados directa o indirectamente en las actividades de I+D e Innovación:		
P2.8. Considerando en su conjunto los últimos 5 años, indique:				
a. % medio de **gastos en actividades de I+D** internas[16] sobre **Ingresos Totales** (incluyendo ingresos de venta de productos y/o servicios, licencias y subvenciones).				
b. % medio de **gastos en actividades de I+D contratadas externamente** (externalizadas)[17] sobre los **Ingresos Totales** (incluyendo ingresos de venta de productos y/o servicios, licencias y subvenciones):				
P2.9. ¿Está su empresa instalada en un Parque científico/tecnológico18?			Sí ☐	No ☐

[15] This questionnaire forms part of the research project and only the extracted part used in this dissertation is presented here.

[16] Trabajos creativos llevados a cabo **dentro de la empresa** para aumentar el volumen de conocimientos y su empleo para idear productos y procesos nuevos o mejorados (incluido el desarrollo de software).

[17] Las mismas actividades de I+D interna pero realizadas por otras organizaciones u organismos públicos o privados de investigación, y **compradas por su empresa**.

[18] Entendemos por parque científico/tecnológico a aquel que se establece en los alrededores o dentro del mismo campus universitario, y en el cual las empresas instaladas realizan investigación básica y/o producción, existiendo, además, un compromiso y una participación activa por parte de la universidad (Veciana, 1990)

P3. Propiedad de la empresa:

P3.1. Desde el nacimiento de la empresa, ¿ha sido adquirida por otra empresa?	Sí ☐	No ☐
P3.2. Indique el % de participación de cada socio en el capital:		
Empresa matriz		
Empresas capital riesgo[19]		
Empleados		
Fundadores		
Business angels[20]		
Entidades financieras		
Otros		
	100%	

P4. Origen de la empresa

P4.1. ¿Surgió la empresa de una innovación biotecnológica-(NBF[21])?			Sí ☐	No ☐
P4.2. Marque con una X si:				
a. Surgió de la Universidad (spin-off):	b. Surgió de otra empresa (spin-off):	c. Su origen fue independiente:		
En relación con el nacimiento de su empresa como spin-off:				
P4.3. Implicaba una actividad nueva para la organización de la que surgió			Sí ☐	No ☐
P4.4. Implicaba un mayor riesgo de fracaso o mayores pérdidas que los negocios básicos de la organización de la que surgió			Sí ☐	No ☐
P4.5. Se caracterizaba por una incertidumbre mayor que los negocios básicos de la organización de la que surgió			Sí ☐	No ☐
P4.6. Ha sido desarrollada con el propósito de incrementar las ventas, beneficios, productividad o calidad de la organización de la que surgió			Sí ☐	No ☐
En cuanto a las fuentes de financiación utilizadas en el momento de creación de la empresa:				
P4.7. ¿Acudió al **Capital riesgo**[19] para su financiación?			Sí ☐	No ☐
P4.8. ¿Qué tipo de capital riesgo fue?			Público ☐	Privado ☐
P4.9. ¿Acudió a **Business Angels**[20] para su financiación?			Sí ☐	No ☐
P4.10. ¿Acudió a **Fondos Públicos** para su financiación?			Sí ☐	No ☐
P4.11. ¿Empleó capital privado?			Sí ☐	No ☐

A continuación, y siempre que **NO SE INDIQUE LO CONTRARIO** utilice la siguiente **ESCALA**: ***1***= *Totalmente en desacuerdo;* ***4***= *Neutro;* ***7***= *Totalmente de acuerdo*

II. ALIANZAS[22] ESTABLECIDAS PARA ACTIVIDADES DE I+D E INNOVACIÓN

P9. Por favor, señale su grado de acuerdo con las siguientes afirmaciones **en relación con la forma en que son gestionadas las alianzas establecidas con otras empresas para la I+D y la Innovación**:

[19] La actividad de capital riesgo consiste en la toma de participación, con carácter temporal y generalmente minoritaria, en el capital de empresas. Además de esto, las empresas de capital riesgo asesoran en la toma de decisiones a las empresas participadas.

[20] Un business angel es una persona con solvencia financiera que aporta dinero, conocimientos y red de contactos a una nueva empresa (Ministerio de Industria, Turismo y Comercio, 2008).

[21] Las siglas NBF corresponden a New Biotechnology Firm

[22] A los efectos de este trabajo, consideramos las alianzas como acuerdos establecidos formalmente entre dos o más organizaciones, con objetivos concretos relacionados con las actividades de I+D e Innovación (Powell, Koput y Smith, 2006).

		Totalmente en desacuerdo						Totalmente de acuerdo
P9.1.	Nuestras actividades con los partners en las alianzas de I+D e innovación están bien coordinadas.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.2.	Nos aseguramos de que nuestro trabajo esté sincronizado con el de nuestros partners.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.3.	Existe una gran interacción con nuestros partners en la mayoría de las decisiones.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.4.	Nos aseguramos de que haya una coordinación adecuada entre las actividades de las diferentes alianzas de I+D e Innovación.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.5.	Establecemos áreas de sinergia en nuestro portfolio de alianzas de I+D e Innovación.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.6.	Tenemos identificadas las interdependencias entre nuestras alianzas de I+D e Innovación.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.7.	Conocemos si existen solapamientos entre nuestras alianzas de I+D e Innovación.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.8.	Tenemos la capacidad de aprender de nuestros partners en las alianzas de I+D e Innovación.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.9.	Sabemos absorber nuevo conocimiento de nuestros partners.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.10.	Disponemos de las rutinas adecuadas para analizar la información obtenida de nuestros partners.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.11.	Sabemos integrar con éxito nuestro conocimiento con la nueva información adquirida de nuestros partners.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.12.	Nos esforzamos por anticiparnos a nuestros competidores iniciando alianzas de I+D e Innovación	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.13.	A menudo tomamos la iniciativa en contactar con empresas con propuestas de alianza de I+D e Innovación.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.14.	Comparados con nuestros competidores somos mucho más proactivos y receptivos en encontrar y "perseguir" colaboraciones para I+D e Innovación.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.15.	Monitorizamos nuestro entorno para identificar oportunidades de colaboración en I+D e Innovación.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.16.	Estamos dispuestos a dejar a un lado los términos contractuales, si con ello se mejora los resultados de la alianza.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.17.	Cuando surge una situación inesperada, modificaríamos el acuerdo de la alianza, más que insistir en los términos originales.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P9.18.	La flexibilidad, en respuesta a requerimientos de cambio, es una característica de nuestro proceso de gestión de alianzas	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

P10. En relación con las **alianzas que su empresa tiene establecidas en los últimos 5 años** con otras organizaciones para actividades de I+D e Innovación, indique el número por tipo de socios y pertenencia a su mismo clúster regional[23]:

	Tipo de socio	Nº de alianzas	De entre ellas, número de alianzas con organizaciones pertenecientes a su mismo clúster regional
P10.1.	Número total de alianzas		
P10.2.	Con Universidades, Institutos y Centros de Investigación		
P10.3.	Con los Clientes		
P10.4.	Con los Proveedores		
P10.5.	Con Competidores		
P10.6.	Con Otros (especifique cuáles):		

[23] Los clústeres hacen referencia a grupos de empresas, pertenecientes a la misma industria o industrias relacionadas, próximas entre sí desde un punto vista geográfico. A los efectos de este trabajo se han considerado clústeres de biotecnología coincidentes con las comunidades autónomas, por ejemplo, Biorregión en Andalucía, Biocat en Cataluña, Bioval en Valencia, Biobasque en el País Vasco, y Madrid Bioclúster, entre otros.

P10.7.	Con empresas farmacéuticas (sean clientes, proveedores, competidores, etc.)		

P11. En relación con TODAS LAS ALIANZAS de I+D o de innovación establecidas en los últimos 5 años realice una valoración general de los resultados obtenidos para su empresa:

		Totalmente en desacuerdo						Totalmente de acuerdo
P11.1.	Se ha mejorado la posición competitiva.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P11.2.	Se han reducido los costes.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P11.3.	Se han mejorado los productos o servicios existentes.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P11.4.	Se han desarrollado nuevos productos.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P11.5.	Se ha mejorado la efectividad en I+D.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P11.6.	Nuestra empresa ha logrado los objetivos fundamentales para los que se crearon las alianzas.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P11.7.	La cooperación con los partners que integran estas alianzas puede ser considerada un éxito.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P11.8.	La cooperación con los partners que integran estas alianzas ha contribuído al crecimiento de la empresa.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P11.9.	Nuestra empresa está satisfecha con los resultados financieros de las alianzas establecidas.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P11.10.	Nuestros partners parecen estar satisfechos con los resultados financieros de las alianzas establecidas.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P11.11.	Nuestra empresa está satisfecha con el resultado global de las alianzas establecidas.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P11.12.	Nuestros partners parecen estar satisfechos con el resultado global de las alianzas establecidas.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

III. ALIANZA MÁS IMPORTANTE DE LOS ÚLTIMOS AÑOS

Piense en la **ÚLTIMA ALIANZA** más **importante en cuanto a los objetivos de innovación perseguidos,** *con la suficiente duración como para saber si los* ***resultados alcanzados son positivos o negativos*** (es decir, si es un éxito o un fracaso).

P12. Para la alianza considerada, indique:

12.1. **Duración** (en número de años):		
12.2. **Objetivo** para el que fue establecida:		
12.3. Marque con una X que organización/es ha/n actuado como **líder/es** de la Alianza:		
a. Su propia empresa:	b. Otra empresa/organización perteneciente a su mismo clúster regional:	c. Otra empresa/organización externa a su clúster regional:
12.4. Indique el **número de socios** que la integra, en cada uno de los grupos considerados, y cuántos de ellos se encuentran dentro de su clúster regional:		
Tipo de socio	**Nº de socios**	**Nº de socios dentro del clúster regional**
a. Universidades, Institutos y Centros de Investigación		
b. Clientes		
c. Proveedores		
d. Competidores		
e. Otros (especifique cuáles):		

f. Empresas farmacéuticas (sean clientes, proveedores, competidores, etc.)		

P13. Para la alianza considerada, indique la **duración** de la relación con cada uno de los tipos de socios que participan en ella (si en cada tipo de socio hubiera más de una organización, piense en aquella con mayor peso en la alianza):

P13.1.	Con Universidades, Institutos y Centros de Investigación	☐ 1-2 años	☐ 3-4 años	☐ 5 o más
P13.2.	Con los Clientes	☐ 1-2 años	☐ 3-4 años	☐ 5 o más
P13.3.	Con los Proveedores	☐ 1-2 años	☐ 3-4 años	☐ 5 o más
P13.4.	Con Competidores	☐ 1-2 años	☐ 3-4 años	☐ 5 o más
P13.5.	Con Otros	☐ 1-2 años	☐ 3-4 años	☐ 5 o más
P13.6.	Con empresas farmacéuticas (sean clientes, proveedores, competidores, etc.)	☐ 1-2 años	☐ 3-4 años	☐ 5 o más

Con empresas farmacéuticas (sean clientes, proveedores, competidores, etc.)

P14. Para la alianza considerada, indique con qué **frecuencia**, las personas de su organización responsables de la *alianza considerada,* interactúa con los diferentes tipos de socios (si en cada tipo de socio hubiera más de una organización, piense en aquella con mayor peso en la alianza):

		1: una vez al mes o menos		4: una media de dos veces al mes		7: diariamente	
P14.1.	Con Universidades, Institutos y Centros de Investigación	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P14.2.	Con los Clientes	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P14.3.	Con los Proveedores	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P14.4.	Con Competidores	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P14.5.	Con Otros	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P14.6.	Con empresas farmacéuticas (sean clientes, proveedores, competidores, etc.)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

P15. En relación con la alianza considerada señale su grado de acuerdo con las siguientes afirmaciones relativas al tipo de relaciones mantenidas con sus partners:

		Totalmente en desacuerdo					Totalmente de acuerdo	
P15.1.	Compartimos las mismas metas e intereses respecto a los proyectos conjuntos	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P15.2.	Estamos motivados para perseguir las metas colectivas en los proyectos conjuntos.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P15.3.	Existe una visión compartida respecto al entorno y los factores claves de éxito	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P15.4.	Consideramos que el futuro de nuestra compañía está relacionado con el de las empresas con las que tenemos establecidas la alianza	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P15.5.	Se ha desarrollado algún tipo de estrategia o plan conjunto para los proyectos comunes	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P15.6.	Podemos confiar en que las empresas con las que mantenemos la alianza no se aprovecharán ni se comportarán de forma oportunista	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P15.7.	Las empresas con las que tenemos la alianza mantienen los compromisos realizados	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P15.8.	Estamos seguros que se hará lo acordado, incluso cuando no haya un contrato escrito que especifique las obligaciones de cada parte	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

P15.9.	En general, entre los participantes existe un clima de cooperación y mutua confianza	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P15.10.	Sentimos una obligación especial de respaldarnos en situaciones difíciles y de apoyarnos mutuamente	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

P16. En relación con la **alianza considerada** señale su grado de acuerdo con las siguientes afirmaciones relativas a las **características del conocimiento** utilizado en el desarrollo de innovaciones:

		Totalmente en desacuerdo						Totalmente de acuerdo
P16.1.	Existe un manual útil que describe los procesos	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P16.2.	La información y reglas de decisión son guardadas en bases de datos electrónicas	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P16.3.	El conocimiento relativo a la alianza está suficientemente explicado por escrito	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P16.4.	El nuevo personal puede aprender fácilmente hablando con el personal que interviene en la alianza	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P16.5.	El nuevo personal puede aprender fácilmente estudiando los manuales existentes	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P16.6.	El conocimiento utilizado en la alianza podría ser aprendido por un competidor fácilmente cogiendo la innovación y examinándola cuidadosamente	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P16.7.	El conocimiento utilizado en la alianza es obvio para todos los competidores	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P16.8.	El conocimiento utilizado en la alianza es fácil de identificar, aún sin experiencia personal	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P16.9.	El conocimiento utilizado en la alianza es complejo (1) vs Simple (7)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P16.10.	El contenido del conocimiento que su organización intercambia en la alianza es similar al del resto de los participantes.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P16.11.	En general, los individuos y organizaciones de la alianza se conocen y pueden considerarse cercanos	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

P17. En relación con la **alianza considerada** señale su grado de acuerdo con las siguientes afirmaciones relativas al resultado de la alianza:

		Totalmente en desacuerdo						Totalmente de acuerdo
P17.1.	Las innovaciones han permitido abrir nuevos mercados	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P17.2.	Las innovaciones han hecho posible el desarrollo de otros nuevos productos	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P17.3.	Las innovaciones fueron técnicamente exitosas	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P17.4.	Se cumplieron los objetivos de ventas (unidades físicas)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P17.5.	Se cumplieron los objetivos de ingresos por ventas (unidades monetarias)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P17.6.	Se cumplió el programa o los plazos	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P17.7.	Se cumplió el presupuesto	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P17.8.	El tiempo se usó de forma eficiente	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
P17.9.	Se cumplieron las especificaciones de calidad	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

GRACIAS POR SU COLABORACIÓN